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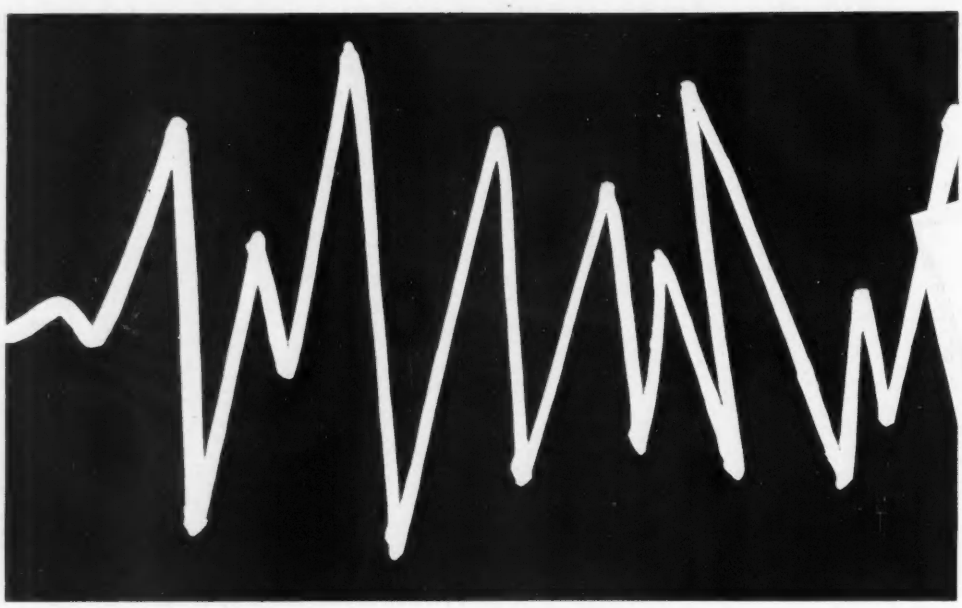

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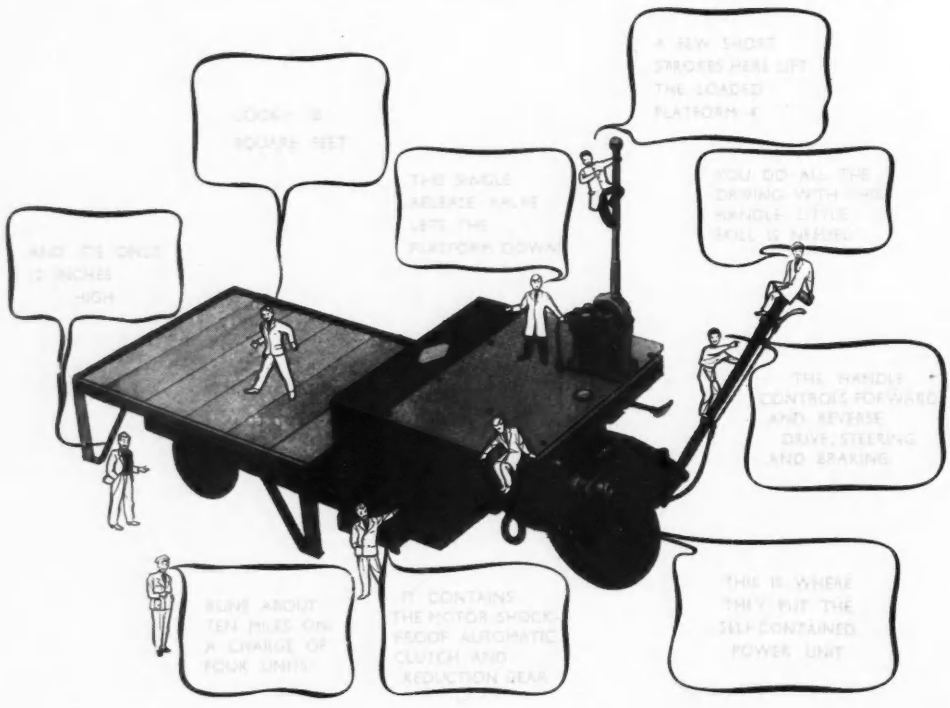

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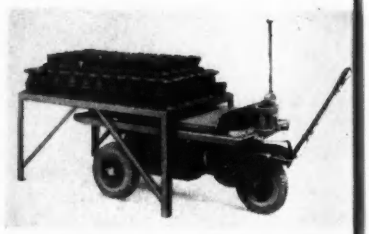

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THE ENGINEER

VOL. 201 No. 5217 JANUARY 20, 1956

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EDUCATION FOR OLDER ENGINEERS

Events that have been eagerly awaited often turn out to be deeply disappointing. The remark applies rather forcibly to the discussion last Monday night of three papers on "Advanced Courses for Engineers in Industry," presented before a joint meeting of the Institutions of Civil, Mechanical and Electrical Engineers and reproduced in abstract elsewhere in this issue. The disappointment does not stem from any complaint about the standard of contributions to the discussion, which was almost uniformly high. The weakness was that those whom the audience would best like to have heard kept almost entirely silent. Much was heard from those who have had the experience of running post-graduate courses for engineers; something was heard from executives of industrial firms, though for the most part only from firms large enough to be able to run internal educational courses for themselves. But no one with experience of undergoing such a course came forward, nor was there any adequate presentation of the views of industrialists about the merits of releasing men to attend them. Indeed, the impression was given—we hope wrongly—that engineering firms as a whole are not interested and the impetus that keeps such courses going comes from the initiative of younger executives desiring to improve their knowledge and seeing in post-graduate courses the chance to do so. That impression was further strengthened by the estimate of at least one speaker that the subjects of not more than 10 per cent of all the post-graduate lectures and courses laid on by universities and colleges are suggested from within industry; suggestions for the rest come from educational establishments themselves and inevitably sometimes fail to meet industrial needs.

Since the war there has been a very large growth in the number of post-graduate courses available. Probably almost every university and technical college in the country provides them. They are designed to "refresh" the knowledge of older executives, to provide knowledge of new theories and techniques, or to give instruction in more specialised subjects to men with some experience of industry who wish to extend their knowledge within their now chosen engineering field. But it does seem to us that a discussion more adequate than that last Monday night might have illumined the situation with advantage. For though the intention behind the organisation of courses is good, there is much that is "hit or miss" about the selection of subjects and, we suggest, a great deal still to be learned about the better ways of presenting them. What real value, for example, is to be assigned to a course consisting solely of a short series of lectures? Is it not true, though teachers may not like to think so, that no subject of any complexity can really be taught; that, in fact, the student, by his own work, under the guidance of a "teacher," must teach himself? If so a student, it seems, can passively imbibe very little; to learn he must be prepared to work. Unless, therefore, a series of lectures inspires students to study a subject for themselves it probably has little value, except, perhaps, if it is directed to senior men who will not have themselves to work in the field covered, but who, having to direct others, wish to have some appreciation of their problems.

To judge by the very large number of courses, combining lectures with discussions or with practical or theoretical work by the students and extending over a few days or, at most, a week or two, there must be plenty of realisation within industry of their value. But what value should be assigned to university courses extending over a much longer period of several months' full time? There are obvious difficulties for any engineering firm, however big, in releasing men for such a length of time. Very probably it becomes impossible for smaller firms. Is there any truth in the argument that, since it is only the larger firms that could afford to release men, courses of such length would be better organised internally by the firms themselves? Which is better, that the course should be conducted in an industrial or an academic atmosphere? Is it true that all firms large enough to release men for such long periods can provide internally equivalent training? Those are problems, mentioned rather than discussed, at the meeting, which need thinking out. But one thing seems to us certain. If this country is to keep in advance, technically, of others, then the means must be provided for disseminating rapidly throughout industry knowledge of the latest techniques of design and manufacture, a thing that can certainly

be assisted by the organisation of short courses. But in addition, industry needs to be provided with a leavening of men capable of technical leadership and of really advanced thinking in terms of theory as well as of practice. For those men relatively long courses of advanced study seem essential once they have settled into any specialised field; and since it seems to us that it is only within certain fields that engineering firms exist of sufficient size to organise their own courses then surely it must be the job of universities, in consultation with and advised by industry, to supply them. The numbers of students involved can never be large. But even for so small a number, considering that men who take such courses should be of outstanding promise, the loss to industry by their release for several months may be appreciable. The loss, however, should be balanced against the lifetime of contributions to engineering advancement that these men will be better fitted to make after undergoing the course.

THE CHANGING CHARACTERS OF INSTITUTIONS

How greatly, even within the memory of men now no more than middle-aged, the characters of the major engineering institutions of this country have changed! Even a mere thirty years ago a really significant proportion of the members of those institutions regularly took part in their activities. So much can hardly be claimed now. It is true, of course, that over a term of years probably quite a high proportion of the members of an institution have had some contact with it more direct than that of paying a subscription or reading its *Journal* or *Proceedings*. They may, for example, have attended, within that period, a Summer Meeting or Conference, if one has been held in their area; or a paper on a specialised subject may have attracted them to a branch or headquarters meeting. But that is a situation very different from the one ruling half a century or so ago when quite a high proportion of the membership regularly attended all meetings, of which at that time there were far fewer. Increasingly the major engineering institutions are tending to become bodies of national importance and even to extend their activities into international technical affairs. They have come to be looked upon by many engineers more as qualifying bodies than as societies asking for service from their members; and they have become bodies through which technical papers may be published rather than discussed. Indeed, the quantity of technical literature they are called upon to print is becoming embarrassingly costly. None of those tasks was to be found amongst the prime purposes of the major institutions when they were originally set up. The prime purpose at that time was to bring engineers together to discuss technical matters or other matters of interest—that is, to bring members into social and technical contact.

The change has come about inevitably. One may regret that the major institutions are no longer the intimate and social societies that they once were. But if they had not chosen to take a deep interest in educational matters, if they had not been led thereby to set up examination standards for membership and thus become qualifying bodies; if, as a result of the consequent acquirement of large memberships they had not become bodies of national importance which the Government and other organisations consult upon a variety of technical matters, then some other bodies would have had to be created to do the work. Certainly the trend cannot now be halted. The present situation, indeed, suggests that those institutions are likely to become still larger in the future, that they will co-operate ever more fully and that their existing links with similar societies abroad will grow increasingly close. But unquestionably the relatively rapid change in their characters has led to certain difficulties. Amongst some of the more active members of those enlarged institutions there is a feeling of frustration. They cannot hope to serve on their councils, for only a tiny minority can ever aspire to that honour; nor do many of them feel that they have either the eminence or the talents to serve there. Yet they would like to serve the Institution and they would like to feel that they had some influence over the Institution's actions and doings. In particular, some members feel frustrated by the difficulty of making suggestions about or criticisms of Institution activities. In very much smaller societies they would know that if such suggestions or criticisms were rejected at least a substantial fraction of the total membership would have heard their arguments. But in a great Institution the individual can only make himself heard effectively by the council itself; and the council has great difficulty in determining the views of the members as a whole.

But far too much can be made of this difficulty—one that has embarrassed most large institutions at times and is acutely embarrassing one of the major institutions at the present. For it hardly affects the main work of those bodies. Over a very large part of the work of the Institution councils there is no division of opinion amongst engineers. They are agreed upon policy. They wish only for it to be carried out with wisdom. Within an advancing technology there can of course be controversies. But in such matters the Institutions stand aside. Their interest is the advancement of knowledge; and they are, indeed, at their very best under such circumstances in providing meetings at which the advocates of conflicting theories or methods can place their views before their fellows. Again, when an Institution is called upon to take external action, as, for example, in making recommendations upon an educational topic to the Government, it is not a difficult matter to organise conferences or a series of meetings at which members particularly interested can air their views and the council (which is, indeed, itself in such a matter likely to be representative) can thus determine the general sense of what members would like to see done. It is only over the domestic affairs of an Institution that any conflict between the council and any section of the membership is likely to arise. Are those conflicts, we wonder, rooted in an insufficient appreciation by some members of the rapid change that has come over the characters of the major engineering institutions? Are those members asking the impossible, that great bodies of national importance should be run as though they were still small and intimate societies? If so, the difficulty may disappear as new generations grow up accustomed to the Institutions as they are and having no memories of what they were.

100 Years Ago

The Engineer

(JANUARY 18, 1856)

"NOTE BOOK"

"It is refreshing to those within the scope of whose duty if falls to wade through the mass of patents, to meet with one possessing something like originality; and readers will thank us for presenting to their notice an invention which, if it does not possess much value as such, is at all events brimful of novelty. Mr. Cruikshank, a farmer, suggests a newly-constructed offensive and defensive equipment for cavalry. . . . We were not present at the celebrated cavalry charge at Balaklava, and we are not quite sure that the newly-proposed offensive equipment would have been of much service in that charge, or would be in any other. We leave that question to be decided by those who are conversant with the subject. . . .

"The Reverend Mr. Berthon offers himself as another example of the consequences of a man mistaking his vocation. This gentleman resigns his incumbency that he may be the better enabled to turn all his attention to, and occupy all his time in, the construction of a mortar-raft, which failed altogether to withstand the concussion consequent upon the discharge of the ordnance it was intended to sustain. It parts asunder, and disappears. Fortunately for the inventor, he had kept at a distance (not from fear, but for the purpose of witnessing the practice), and so escaped without hurt. One poor fellow was, however, not so fortunate. We trust Mr. Berthon will think no more of mortar-rafts. It ill becomes the minister of peace to renounce his mission, and devote the talent he possesses to the fabrication of war implements and the construction of war craft."

A Seven Day Journal

160ft Span Reinforced Concrete Dome

THE design and construction of a domed roof for a reservoir 160ft 6in in diameter was described at the Institution of Civil Engineers on Thursday, January 12th, when the paper, "The Roofing of Cleadon Reservoir," by N. J. Ruffle and H. Tottenham was read at a meeting of the structural and building engineering division. The chief reason for building a single-span roof was to avoid disturbance of the puddle-clay floor of the reservoir, and the ring beam of the dome is carried on a reinforced concrete capping beam, built on the existing masonry wall of the reservoir. The dome is 3in thick, except for the outer 15ft, where it thickens to 10in at the junction with the ring beam ; its total weight is 560 tons. It is reinforced with a central layer of circumferential bars at 6in centres, between two layers of radial bars at centres varying from 3in to 6in, all these bars being ¼in in diameter. There is additional reinforcement in the edge zone of the shell, principally to resist the hoop tension and radial bending moments arising from the edge forces. The ring beam is 2ft wide by 3ft deep and its principal reinforcement consists of twenty-six 1¼in diameter bars, equally spaced over the cross-section. Design of the dome is discussed quite fully in the paper, and various approximate methods of analysis are compared, with curves showing radial bending moments and circumferential stresses computed by the various methods. An account of a new method of approximate analysis is included. The dome was built for the Sunderland and South Shields Water Company at a cost of almost £30,000. It was designed by Twisteel Reinforcement, Ltd., in collaboration with the engineering staff of the Sunderland and South Shields Water Company, and the contractor was William Moss and Sons, Ltd.

Report on Prc 'uction Control

THE joint committee formed by the Institute of Cost and Works Accountants and the Institution of Production Engineers for investigating the measurement of productivity has just issued a report on *Production Control and Related Works Statistics*. This report is based upon 229 completed questionnaires from firms in fourteen different industries. It is primarily designed to define production control and workshop statistics and show that together they form an essential part of management control, and to dispel some misunderstandings and misconceptions. The report also sets out to describe the paramount factors and statistical returns necessary on any efficient and economical control, and to determine the minimum economic control that might be applicable in a large number of small concerns in which production control is difficult. The first section of the report outlines the scope of the inquiry and summarises the conclusions ; the second part discusses production control in detail, and includes a special section relating to the smaller firm. Amongst the general conclusions it is stated that production control is an important factor of managerial function deserving of its own line of responsibility direct from the senior executive. Production control, the report says, will only be as efficient and effective as the works statistics are accurate, simple and up-to-date, and a production plan is essential even if it is liable to be amended. In many firms a method of measuring capacity, production and, if possible, cost in common units, the report suggests, is urgently needed. There are many systems of budgetary control and costing which make the introduction of such a common method of measuring possible. The report is being distributed by Gee and Co. (Publishers), Ltd., 27–28, Basinghall Street, London, E.C.2, and costs 5s. per copy.

Canadian Hydro-Electric Power

EACH year, at about this time, the water resources branch of the Canadian Department of Northern Affairs and Natural Resources publishes a progress report of the previous year's achievements in hydro-electric construction. The report for 1955 notes that new plant totalling almost 840,000 h.p. was installed during the year, bringing the total water power installations in Canada to over 17½ million horsepower in capacity. Over half of the 1955 total was for new plant at the Sir Adam Beck-Niagara generating station of the Ontario Hydro-Electric Power Commission (see THE ENGINEER, October 1, 1954), and the remainder was in comparatively small projects well distributed across the country. It is expected that installation of at least a million horsepower will be completed in Canada in each of the years 1956 and 1957. In fact, construction of electrical power installations, including steam stations, continues to progress vigorously. Quebec is the province with the largest installation of hydro-electric power. The province's major project on the Bersimis River made good progress during 1955, and construction of the main dam near the outlet of Lake Casse was nearly completed. Excavation for the tunnel, which is 7½ miles long and 31ft in diameter, and for the underground power station, was completed and the surge tank excavation was well advanced. Installation of the first three turbo-alternator sets, each of 138MW capacity, was in progress.

Fiftieth Anniversary of "Concrete and Constructional Engineering"

THE current issue of our contemporary journal, *Concrete and Constructional Engineering*, marks the fiftieth anniversary of its publication, and consists of a number of articles written by well-known engineers of various nationalities, each writing of progress in the structural uses of concrete in his own country. It is pointed out in the introduction that fifty years covers nearly the whole of the history of reinforced concrete in Great Britain, where the first structures were built a few years earlier. The journal had to popularise a material "in which few were interested and against which many were prejudiced." The anniversary number includes descriptions of some of the early reinforced concrete works of those days.

Report on Roadway Conveyors in Coal Mines

THE National Coal Board has just published the report of the committee appointed in November, 1952, to inquire into the safety and economic aspects of roadway conveyors in coal mines. This committee was formed following the report made by the Chief Inspector of Mines on the explosion at the Easington Colliery in May, 1951, when he recommended that the use of roadway conveyors in the mining industry should be investigated with a view to determining the limits within which they might be safely and advantageously used. In preparing the report the committee drew most of its information from internal sources, but it also invited the views of interested trade unions, professional and engineering bodies and the manufacturers primarily concerned. The report points out that underground conveying has been adopted for two main reasons. First, it is the only ready means of obtaining more efficient transport with the existing layout of roadways and workings ; and, secondly, it will often be the best system of transport consistent with newly planned layout. Altnough in some cases enthusiasm for conveyors has tended to overrun itself, it is explained in the report that conveying is virtually inescapable for certain purposes and for many others gives great advantages in safety, efficiency and overall cost. For the purposes of the report the committee chose to examine the problems involved under five main headings : the place of conveying in underground roadway transport ; the safety aspect ; the practical limits and economic aspects of roadway conveying ; conveying design and practice ; and new developments in conveying. The conclusions reached are summarised in the report and one of the principal ones is that the N.C.B. should issue a Code of Practice on the planning and use of roadway conveyors.

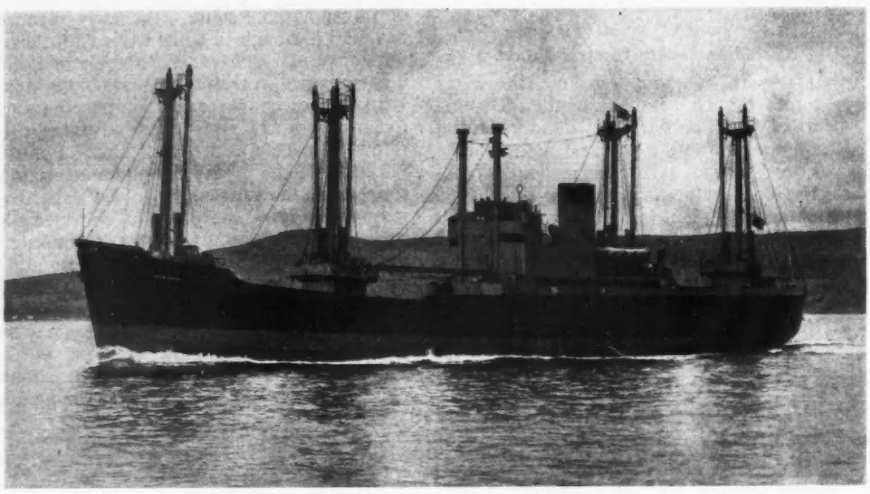
Sir Felix Pole

ENGINEERS and industrialists generally will regret the death of Sir Felix Pole, which occurred on Sunday last, January 15th. It will be remembered that he spent nearly forty years in the service of the Great Western Railway Company, of which he was general manager from 1921 to 1929. Sir Felix, who was born in 1877, joined the Great Western at the age of fourteen and for a start worked in the telegraph department at Swindon. His railway career was a distinguished one, culminating, as it did, in his being appointed general manager in 1921, when he was forty-four. His grasp of railway practice and his organising ability stood him in good stead, for his years as general manager were those in which the problems following the grouping of the railways had to be satisfactorily solved. There is no doubt that Sir Felix was more than equal to that task. But his expert advice was also sought on railway problems apart from those of the Great Western, and twice he visited the Sudan at the invitation of the Sudan Government to report on railways and steamers. Sir Felix relinquished the chairmanship of the Great Western Railway in 1929 and was then appointed chairman of Associated Electrical Industries, Ltd., in which position he remained until 1945. In 1946 he succeeded the late Mr. W. C. Lusk as chairman of The British Thomson-Houston Company, Ltd., and retired from the board of that company and from the board of Associated Electrical Industries, Ltd., in 1954. During his years in the electrical industry, Sir Felix was called upon for many public services. Among them were membership of the Colonial Development Advisory Committee and the Coal Commission, the chairmanship of the Rural Housing Committee, membership of the Committee on the Fishing Industry, and of the Police Pay (New Entrants) Committee. Sir Felix was also invited in 1934 to report on transport conditions in Northern Ireland. The honour of knighthood was conferred upon him in 1924.

Shipbuilding and Marine Engineering in 1955

No. III—(*Concluded from page 59, January 13th*)

THE smaller cargo ships built in 1955 included the "Tynemouth," constructed by Smith's Dock Company, Ltd., for the Burnett Steamship Company, Ltd. The ship has a length between perpendiculars of 350ft by 51ft breadth moulded by 25ft 3in depth moulded to main deck and a deadweight capacity of 5505 tons on 21ft 0½in draught. Six 5-ton and two 10-ton derricks operated by steam winches handle the cargo carried in four holds and a speed of 12½ knots is maintained by a triple-expansion engine having cylinders 18¾in, 30½in and 52in diameter by 36in stroke, working in conjunction with a Bauer-Wach exhaust turbine, and developing a total of 1550 i.h.p. at 90 r.p.m. Two single-ended multitubular boilers supply steam at 220 lb per square inch and 580 deg. Fah.



5300 tons deadweight motorship "Kawerau"

Alexander Stephen and Sons, Ltd., completed the M.V. "Kawerau," illustrated above, for the Union Steam Ship Company of New Zealand, Ltd. The dimensions of the ship are length 325ft, beam 50ft, depth 26ft, the deadweight 5300 tons, and propulsion is by a Stephen-Sulzer single-acting diesel engine developing 2410 b.h.p. at 128 r.p.m. and a maximum of 3000 b.h.p. at 150 r.p.m. and having six cylinders of 600mm diameter and 1040mm stroke. Electric deck machinery is fitted and twelve derricks serve three large hatchese quipped with MacGregor covers.

Short Sea Traders

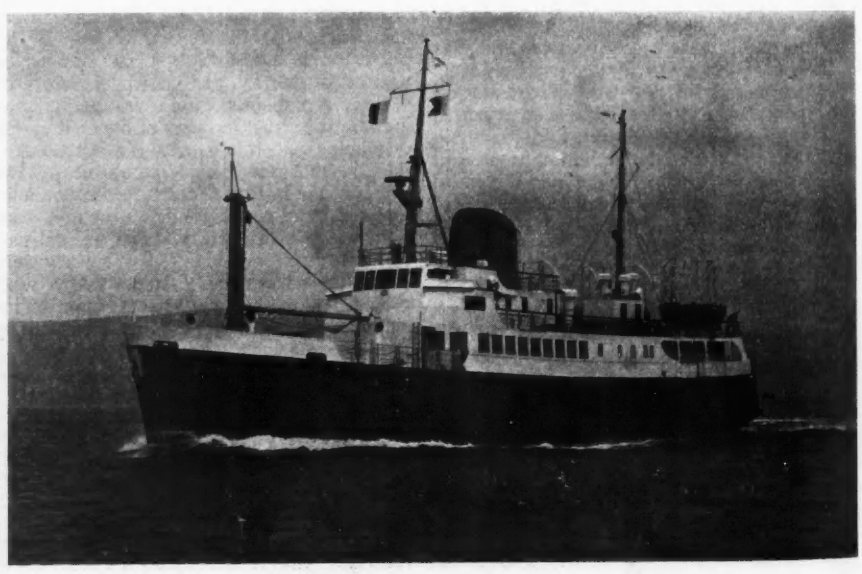
The R.M.S. "Claymore," seen in our illustration, was designed and built by William Denny and Brothers, Ltd., to carry passengers, mails, motor-cars, cargo and cattle on the West Coast of Scotland service of David MacBrayne, Ltd. A deadweight of 135 tons is carried on 9ft draught and the ship has a length overall of 192ft, a moulded breadth of 35ft, and a depth moulded to the promenade deck of 20ft 9in. There are comfortable cabins and public rooms for both first and third class passengers. Electrical requirements are met by three 65kW diesel-driven generators and the ship is propelled at 12½ knots by two sets of four-cylinder, trunk piston, two-stroke Denny-Sulzer diesel engines, which develop a total of 1200 b.h.p. at 250 r.p.m.

Among the ships completed by Henry Robb, Ltd., was the "Navua" for the Union Steam Ship Company of New Zealand, Ltd., and the "Zealand" for the Currie Line, Ltd. The "Navua," which is specially equipped for the carriage of bananas, has a deadweight of 2000 tons on 16ft mean draught, four holds of 105,000 cubic feet capacity and the following dimensions: length between perpendiculars 250ft, breadth moulded 41ft 6in, and depth moulded to upper deck 17ft 9in. Cargo handling is by electric winches and ten 5-ton derricks and three 114kW diesel-driven generators provide power for the auxiliaries, while the propelling machinery, which gave the ship, in ballasted condition, a speed of nearly 13 knots, consists of a five-cylinder, two-stroke Clark-Sulzer Mark T.P.D. 48 diesel engine of 1500 b.h.p. at 225 r.p.m. The upper illustration on page 85 shows the "Zealand," which was designed for her owner's service between Leith and Copenhagen and has the following main particulars: length between perpendiculars 270ft, breadth moulded 45ft, depth moulded to upper deck 25ft 6in, deadweight 1850 tons on 17ft 3in mean draught, and a service speed of 13 knots. Six double cabins are provided for passengers and the four cargo holds, three of which are insulated, have MacGregor hatch covers and are served by two 3-ton, six 5-ton and two 7½-ton derricks, and ten electric winches. Auxiliary power is supplied by three 230kW diesel-driven and the main propelling machinery consists of two seven-cylinder, two-stroke, unidirectional British Polar diesel engines which develop a total power of 2620 b.h.p. at 300 r.p.m. and drive a single propeller at 125 r.p.m. through two Barclay Curle "Vulcan" hydraulic couplings and a M.W.D. reverse reduction gearbox.

During the year Cammell Laird and Co. (Shipbuilders and Engineers), Ltd., completed the cross-channel steamer "Manxman" for the Isle of Man Steam Packet Company, Ltd., and the ship, which we show on her trials on the Clyde, can carry 1049 first class and 1344 third class passengers, for whom comfortable accommodation is provided, consisting of a limited number of private cabins, lounges, smoking rooms, dining saloons, sleeping saloons, and buffets and bars on several decks. The ship, which was described in our issue of July 1, 1955, has a length overall of 344ft 3in, a length between perpendiculars of 325ft, a breadth moulded of 47ft, a depth moulded to shelter deck of 26ft and a gross tonnage of 2405. A service speed of 21 knots is maintained by two sets of single-casing, double-reduction geared Pametrada turbines, which have a total service power of 8500 s.h.p. at 275 propeller r.p.m. and develop a maximum of 9000 s.h.p. A Weir closed feed system is installed and two Babcock and Wilcox single-pass header boilers, which operate under closed stokehold conditions, supply the necessary steam, while two 200kW diesel-driven generators meet the power demands of the ship services and the auxiliary machinery.

Oil Tankers

Early in the year the trials were completed of the S.S. "Sirius," built by the Furness



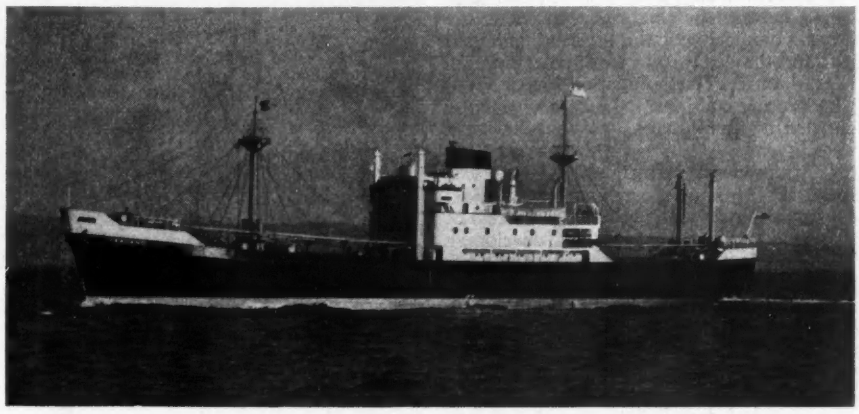
MacBrayne motorship R.M.S. "Claymore"

Shipbuilding Company, Ltd., for the Sociedad Transoceanica Canopus S.A. This ship of 24,900 tons deadweight on a draught of 32ft 4in has a length between perpendiculars of 560ft, a breadth moulded of 80ft and a depth moulded of 42ft 3in. There are twenty-seven cargo oil compartments, all fitted with heating coils, and one main cargo pump room equipped with three 1000 tons per hour turbo-driven pumps and three 150 tons per hour vertical duplex stripping pumps. Two 325kW turbo-generators supply electric power and the ship, which had a loaded trial speed of 14¼ knots, is powered by a set of Richardsons, Westgarth double reduction geared turbines. The machinery develops 7300 s.h.p. at 100 propeller revolutions per minute, and a maximum of 8200 s.h.p. at 104 r.p.m., and takes steam at 450 lb per square inch and 750 deg. Fah. from two Foster Wheeler boilers.

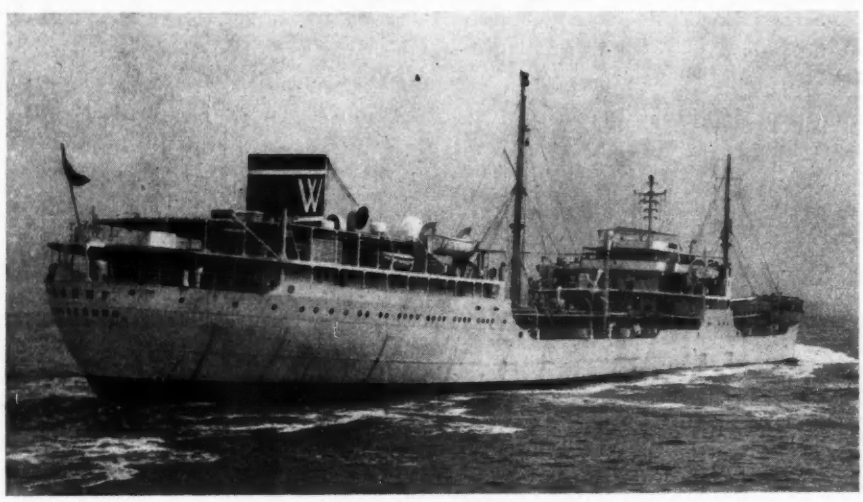
Barclay, Curle and Co., Ltd., built and engined the "Polarprins," the third of three ships for the same Norwegian owners. The dimensions are: length 557ft, breadth 73ft 9in, depth 40ft, and the deadweight 18,300 tons. Four steam pumps in two cargo pump rooms handle the oil cargo, which is carried in twenty-seven tanks and there is one stripping pump. The whole of the accommodation is air conditioned. A six-cylinder Barclay-Curle-Doxford oil engine of 750mm bore by 2500mm combined stroke propels the ship, and has three scavenge pumps and also a Doxford Bibby detuner fitted at the forward end of the crankshaft. Steam for auxiliaries is provided by two cylindrical multi-tubular boilers.

Another ship completed for Norwegian owners was the "Karmt," which is shown in our illustration and was constructed by the Furness Shipbuilding Company, Ltd. The ship has a length overall of 556ft 5in, a breadth moulded of 71ft, a depth moulded of 39ft 3in and carries a deadweight of 18,190 tons on a Lloyd's summer draught of 30ft 6in. There are nine treble cargo oil tanks and two pump rooms, each of which is equipped with two 400 tons per hour horizontal duplex steam cargo oil pumps and one stripping pump. The cargo piping is of 12in diameter. Electric power is supplied by three 160kW diesel-driven generators and the ship is propelled by a Hawthorn-Doxford single-acting, two-stroke opposed-piston oil engine having six cylinders of 670mm diameter by 2320mm combined stroke and developing 6600 b.h.p. at 115 r.p.m. Two Scotch boilers and a "Swirly flow" waste heat boiler supply all the steam.

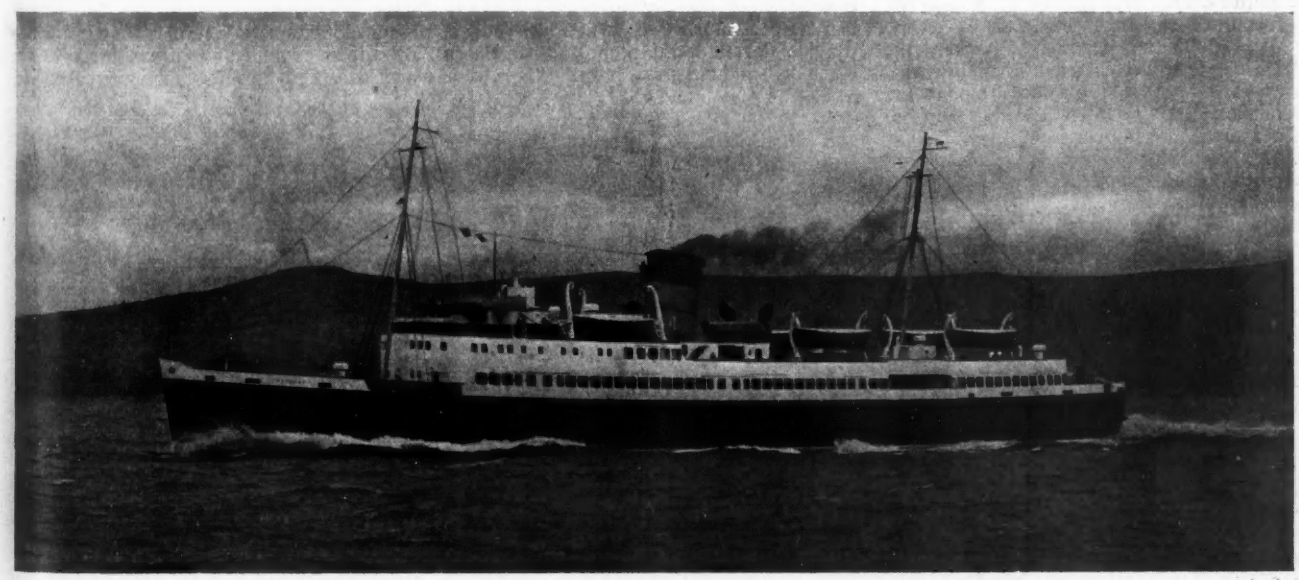
The "Vestvard," delivered by Smith's Dock Company, Ltd., has these particulars: length between perpendiculars 530ft, breadth moulded 71ft, depth moulded 39ft and a deadweight capacity of 18,178 tons on 29ft 8¼in draught. The oil carried in twenty-seven compartments is handled by four 500 tons per hour cargo oil pumps and two drain pumps mounted in two pump rooms. Steam for the auxiliary machinery is supplied by two Scotch boilers and a Spanner waste heat boiler, and electric power is provided by



Twin-screw motorship "Zealand"



Motor tanker "Karmt"



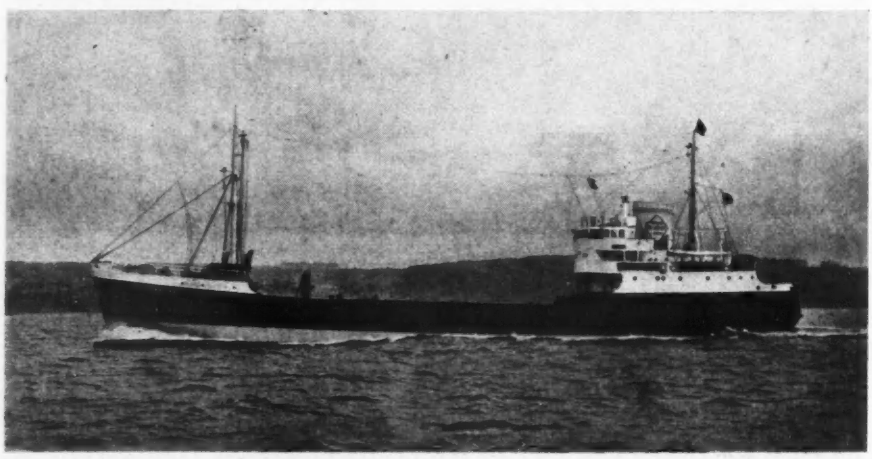
Turbine steamer "Manxman"

two 50kW steam-driven generators and one 50kW diesel-driven generator. John G. Kincaid and Co., Ltd., built the Harland and Wolff seven cylinder, single-acting, opposed-piston diesel engine of 750mm bore by 2000mm combined stroke, which has an output of 7600 b.h.p. at 110 r.p.m.

Among the ships joining the fleet of Shell Tankers, Ltd., was the "Hinea," built by Vickers-Armstrongs (Shipbuilders), Ltd. The length between perpendiculars is 530ft, the breadth moulded 69ft 3in, the depth moulded 39ft and the deadweight to summer draught 18,000 tons. Thirty-three oil tanks fitted with heating coils carry the cargo, which is handled by four 400 tons per hour Hayward Tyler turbine-driven pumps and two 150 tons per hour stripping pumps. A service speed of 14½ knots is maintained by a set of double reduction geared turbines, of Pametrada design, capable of developing 7500 s.h.p. at 100 propeller revolutions per minute in service and a maximum of 8250 s.h.p. at 103 r.p.m. The h.p. ahead turbine is of impulse pattern, while the l.p. turbine is of single flow impulse-reaction design; two Foster Wheeler boilers supply steam at 500 lb per square inch and 800 deg. Fah. The electrical installation consists of two 550kW, 60 c/s turbo-alternators and a 200kW diesel-driven alternator. A sister vessel, the

Twin-screw steam tug "Barana"

tanks and six summer tanks. There is one main pump room fitted with two horizontal duplex pumps for loading and discharging cargo, and two vertical duplex pumps for dealing with special cargoes, while a rotary pump for molasses is placed in the engine-room. The



Bulk cargo ship "Golden Bay"

"Haminen," was built by Smith's Dock Company, Ltd., and engined by R. and W. Hawthorn Leslie (Engineers), Ltd.

A 16,300 tons deadweight tanker, the "Hermes," was completed for Norwegian owners by the Blythswood Shipbuilding Company, Ltd., in July. The ship's dimensions are: length between perpendiculars 510ft, breadth 68ft, and depth moulded 38ft, and the cargo oil is carried in twenty-one compartments consisting of nine centre tanks and twelve wing tanks. Two 400 tons per hour vertical duplex compound cargo oil pumps in each of two pump rooms handle the cargo oil. A 6200 b.h.p. Rowan-Doxford two-stroke, opposed-piston oil engine, having five cylinders of 700mm diameter by 2320mm combined stroke and arranged to burn heavy gravity fuel, gave the ship a trial speed of 14¾ knots in load condition.

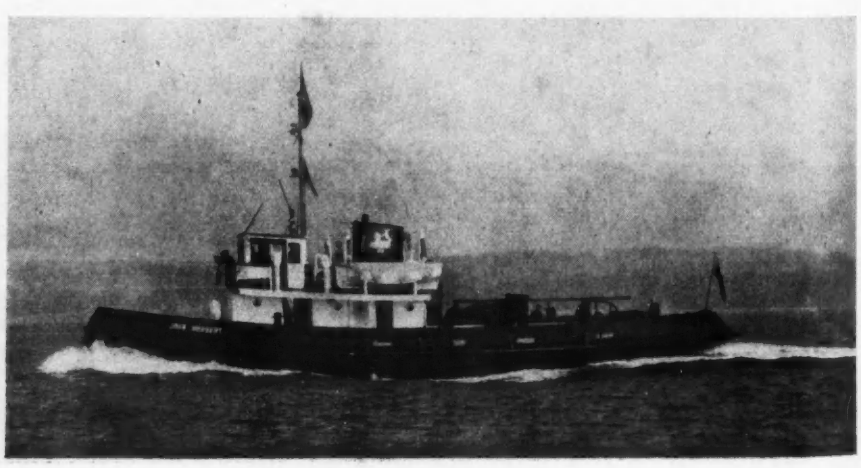
The Athel Line took delivery from Hawthorn Leslie (Shipbuilders), Ltd., of the M.V. "Athelstane" which was designed for the carriage of molasses, oil or spirits and a variety of liquid chemicals. A deadweight of 10,000 tons is carried on the following dimensions: length overall 459ft, breadth moulded 61ft, and depth moulded 31ft, the cargo space is divided into ten pairs of

electrical installation consists of two 100kW diesel-driven generators and one 50kW steam-driven generator, two cylindrical boilers provide steam for the pumps and auxiliary machinery and the ship is propelled by a four-cylinder Hawthorn-Doxford diaphragm oil engine which has an output of 4450 b.h.p. at 112 r.p.m.

Some other tankers delivered in 1955 were shown in Plate 4 in our January 6th issue.

Special Ships

One illustration shows the T.S.M.V. "Golden Bay," which was designed and built by Henry Robb, Ltd., for the Tarakohe Shipping Company, Ltd., of New Zealand, to carry cement or coal in bulk. She is fitted with special mechanical handling equipment for the loading of the cement cargo and the discharge of both cargoes. A total of 1200 tons of cement or 1000 tons of coal can be carried in two holds, arranged one to port and one to starboard, and in each there is a travelling crawler conveyor and a scraper conveyor for unloading, and air slides for loading the cement. Cement can be loaded at the rate of 360 tons per hour. The ship has a length between perpendiculars of 230ft, a breadth moulded of 42ft, a depth moulded to upper deck of 18ft, a deadweight of 1400 tons, on 14ft. draught, and the hatches are fitted with MacGregor steel covers. Two British Polar Mark M.44.M. two-stroke, single-acting diesel engines give the ship a service speed of 10 knots. Each has four cylinders of 13⅜in diameter by 22⅞in stroke and develops 630 b.h.p. at 250 r.p.m., the final drive being through B.T.H. electro-magnetic coupling alternator units, which operate as couplings when the ship is at sea and as alternators for supplying electrical



Twin-screw tug "John Herbert"

power when the ship is in port. These alternators each develop 500kW and, in addition, there are three 60kW and one 30kW diesel-driven generators.

William Denny and Brothers, Ltd., handed over to the Scottish Home Department the twin-screw motor patrol vessel "Freya," which replaces an earlier ship of the same name and has been designed for fishery patrol service in Scottish waters. The principal dimensions are: length 145ft, breadth moulded 24ft, depth moulded 10ft 6in. Three 20kW diesel-driven generators supply electrical power and the ship is propelled by two four-cylinder Sulzer diesel engines having a total continuous output of 1000 b.h.p. at 420 r.p.m.

Among the colliers delivered to the Central Electricity Authority were the S.S. "James Rowan" and S.S. "Sir John Snell," both built by Hall, Russell and Co., Ltd. Each ship is a single-screw, raised quarter deck, self-trimming collier carrying a deadweight of 3700 tons on a load draught of 18ft and the following dimensions: length between perpendiculars 323ft, breadth moulded 43ft 3in, and depth moulded 20ft 3in/25ft 9in. There are four separate holds, suitable for grab discharge and fitted with steel hatch covers, and steam deck machinery. The propelling machinery, supplied by The North Eastern Marine Engineering Company, Ltd., consists of direct-acting triple-expansion steam engine of "North Eastern Reheat" design, which has a service power of 1475 i.h.p. and operates on superheated steam at 220 lb per square inch, generated in two oil-fired forced draught cylindrical boilers.

John I. Thornycroft and Co., Ltd., completed the twin-screw steam tug "Barana," illustrated herewith, for the Government of Ceylon. The tug was designed for duties in Colombo harbour and has a length overall of 122ft 6in, a breadth moulded of 31ft 6in, a depth moulded of 14ft 6in, and a maximum draught of 13ft. Fire-fighting equipment is installed and the tug has a maximum running free speed of 13 knots and a maximum static towing pull of 22 tons. The two triple-expansion, surface-condensing, reciprocating steam engines have cylinders of 13½in by 21½in by 35in diameter, and a stroke of 27in, and develop a total of 1564 i.h.p. at 138 r.p.m. They are supplied with saturated steam, at 200 lb per square inch, by two single-ended, oil-fired, hot-air forced draught Scotch boilers.

Two twin-tunnel screw tugs, the "Al Thoraya" and "Al Nigm El Gutbi," were completed by William Denny and Brothers, Ltd., for the Sudan Government express passenger service on the Nile between Wadi Halfa and Shellal. Each vessel has a waterline length of 145ft, a moulded breadth of 30ft, a moulded depth of 7ft, a maximum loaded draught of 2ft 9in, and two-berth cabins for a number of first and second class passengers. Provision is made for towing two barges, one on each side, and the bow structure is designed so that additional barges may be pushed. Each tug is propelled by two Ruston and Hornsby Mark 6 VEBM four-stroke, airless injection, fresh-water-cooled, diesel engines, each having six cylinders of 10½in bore and 14½in stroke and an output of 324 b.h.p. at 500 r.p.m.

One of the smaller tugs completed during the year was the "John Herbert," which was constructed for the Ribble Navigation and Preston Docks Board by Henry Robb, Ltd. The vessel, seen in our illustration, is 92ft length overall by 23ft breadth moulded by 11ft 6in depth moulded, and has been designed to work on a mean draught of 9ft. There is an electric windlass and steering gear and auxiliary power is provided by two diesel-driven generating sets, while the main machinery consists of two five-cylinder, two-cycle Crossley diesel engines developing a total of 740 b.h.p. at 300 r.p.m.

A single-sided, offshore, all-welded floating dock, having a lifting capacity of 700 tons, was completed by John Lewis and Sons, Ltd., to the order of the Aberdeen Harbour Commissioners. The dock has an overall length of 180ft, a width of 42ft 6in, a pontoon 7ft 6in deep, and a side wall 29ft 6in high, and is capable of being sunk to give a depth of 16ft of water over the keel blocks. The pumping installation consists of two 1560 tons per hour electrically driven centrifugal pumps supplied by Stothert and Pitt, Ltd. Mechanical bilge blocks and side shores, operated from the side wall deck, are installed and the dock is moored to the quayside by upper and lower steel booms.

Gas Turbines in 1955

No. II—(*Continued from page 62, January 13th*)

IN what follows we review the progress made in the design, construction and operation of gas turbines built by some of the principal firms on the Continent of Europe.

Brown-Boveri and Co., Ltd., Baden

We learn from British Brown-Boveri, Ltd., of 75, Victoria Street, London, S.W.1, that the year 1955 marked a further increase in the number of orders placed with the firm for the construction of gas turbines driving alternators.

These orders included one for the third mobile power station for the Comision Federal de Electricidad, of Mexico, having a designed output of 6·2MW and accommodated in two railway carriages along with transformers and switchgear. The two earlier sets were completed and shipped last year, and a description of these interesting units will be found in our review of Continental Engineering, which appears in our issue of January 6, 1956. Other orders included four 6MW single-shaft sets for a new power station in Saudi Arabia, two 9MW single-shaft sets for two installations in Canada, two 10MW single-shaft sets for a power station in Palestine, and two 12MW single-shaft sets for a power station in Algeria. Orders were also received for six 25MW/30MW two-shaft sets for installations in Italy, Sweden, Venezuela and Canada. Some of these sets have alternator ratings of 37·5MVA at 0·8 power factor, in order to permit the alternators to generate up to 30MW during seasons of low air temperature. Four other orders were also received for gas turbine sets in which, in addition to alternators, blowers for steel works were coupled to the turbine shaft. The net output for two of these sets is 7·3MW, and 14MW for the other two sets. These plants are for Luxembourg, France, Germany and Austria respectively.

From the list given above it will be noted that the total number of industrial gas

Running Record of Brown-Boveri Gas Turbine Sets for Electric Power Generation

Plant and country	Commissioning date	Output, kW	Operating hours	Total kWh generated	Up to
Filaret, Rumania	December, 1951	10,000	5,124	41,580,000	March 29, 1954
Chimbote, Peru	July, 1949	4,000	9,007	4,551,000	July 15, 1955
Santa Rosa, Peru	October, 1949	10,000	12,743	93,628,800	July 21, 1955
Pertigalete I, Venezuela	November, 1949	1,650	22,695	27,126,700	July 31, 1955
Pertigalete II, Venezuela	October, 1949	1,650	22,493	25,828,400	July 31, 1955
Pertigalete III, Venezuela	January, 1953	5,000	17,024	61,570,000	July 31, 1955
Pertigalete IV, Venezuela	April, 1955	5,000	3,098	12,729,000	July 31, 1955
Arcache, Egypt	September, 1949	1,200	7,228	4,880,500	July 15, 1955
Beznau, Switzerland	January, 1948	13,000	11,500	118,277,000	July 1, 1955
Beznau, Switzerland	January, 1949	27,000	9,000	181,180,000	July 1, 1955
Dudelange, Luxembourg	March, 1951	5,400	26,087	160,820,000	July 1, 1955
Dhahran, Saudi-Arabia	May 23, 1954	5,000	7,410	38,336,000	July 31, 1955
Dhahran, Saudi-Arabia	April 20, 1954	5,000	8,962	35,735,000	July 31, 1955
Dhahran, Saudi-Arabia	December 16, 1954	5,000	4,711	17,412,000	July 31, 1955
Dhahran, Saudi-Arabia	Summer, 1955	5,000	—	—	—
Vermilion, Canada	October, 1954	6,000	4,057	20,544,000	July 21, 1955

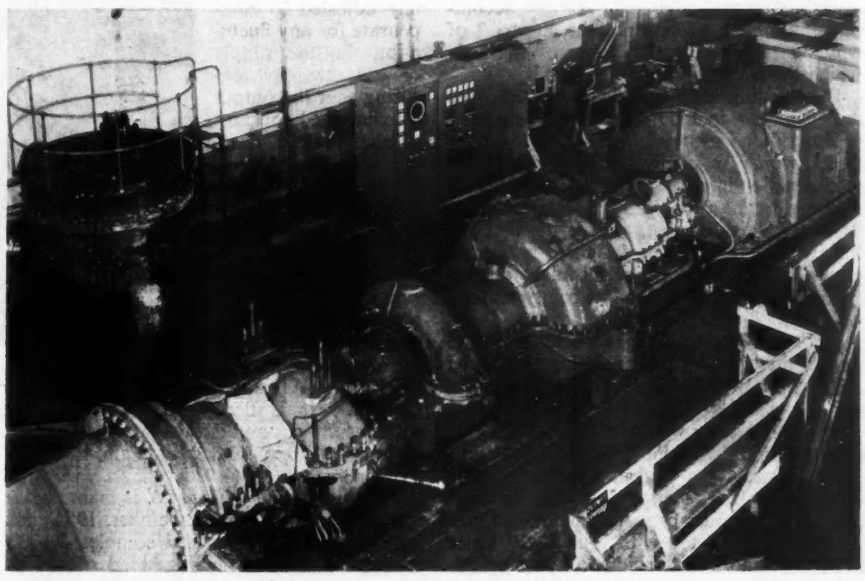


Fig. 6—High-temperature gas turbine at St. Dizier, France

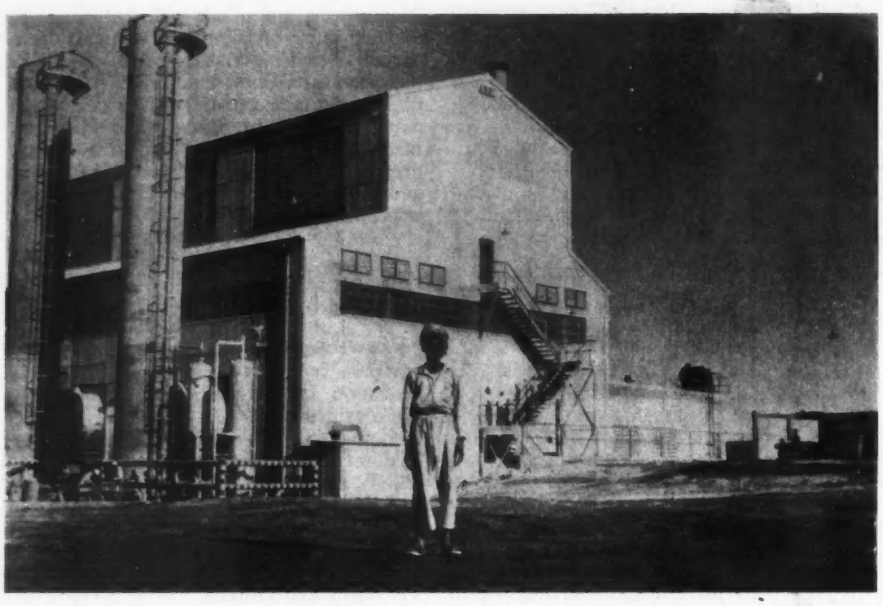


Fig. 7—Four 5MW gas turbine power station at Dharan, Saudi Arabia

turbines for electricity generation ordered during 1955 amounts to twenty-one sets, with an aggregate net output of 294·4MW, which brings the grand total of gas turbine-driven alternator sets so far supplied, and on order, to fifty-two units with an aggregate terminal capacity of 519MW. Individual machine ratings vary between 1·2MW and 30MW. Of these units, twenty-eight sets are for operation on heavy boiler oil, fourteen for natural gas and nine for blast-furnace gas, also one on distillate oil. Some sixteen sets are intended for peak loads and seasonal operation, and the remainder for continuous service.

Of the continuous service machines, several have already run for 25,000 hours and various sets are started up and stopped each day. By midsummer, 1955, sixteen units had been in commercial operation, several of which had run for over 20,000 hours.

The gas turbines now in course of manufacture at the company's works embody all the experience which has been gained in eighteen years of pioneer development, behind which are 840,000 hours of site service, and over 800,000,000kW hours of electrical power generated. In the accompanying table we reproduce the latest list of running records for a number of the sets, which list is dated August 25, 1955.

Outstanding sets completed in the year under review include one set, which after prolonged and successful running tests at the Baden works, was delivered to the St. Dizier power station in France. It is shown in Fig. 6 undergoing the running tests. The machine is of particular interest, as it is the first gas turbine which has been designed to operate continuously with a turbine gas inlet temperature of 1380 deg. Fah., the fuel being distillate oil.

Another interesting gas turbine is the first of the two 25MW generating sets to be installed in the Livorno power station in Italy.

In Fig. 7 we show one of the four power stations in the Middle East equipped with Brown-Boveri gas turbines, namely, the Dhahran power station of the Arabian American Oil Company (Aramco). It has now been completed with four 5MW units in service, and an extension to house a fifth unit is in course of construction. Steps are also being taken to accommodate a sixth, possibly larger, gas turbine set. From the illustration it will be noted that the roof of the power house has been extended to house the air inlet louvres and the air-cooled oil coolers, which are built-in behind them. The coolers are thus fully exposed to the air flowing through on its way to the compressors and the combustion chambers. This construction has been found to be very effective in enabling the power station to continue work during violent sand storms, as the sand particles are less concentrated at roof level than at the ground level. One of the combustion chambers has been equipped with a combined gas-oil burner of the kind which has already given good service in Velox boilers and gas turbines. This special burner enables oil and gas to be burned simultaneously or separately. It is possible to switch from one fuel to the other during operation. When both fuels are being burned together the flow of oil can be automatically adjusted to compensate for any fluctuation in the supply of gas, thereby ensuring that the output is maintained constant at the desired level, when the supply of gas is suddenly interrupted or is inadequate.

Finally, reference may be made to the running of 6MW single-shaft generating set installed at the Vermilion power plant in Alberta, Canada. It is fired with natural gas and is rated at 6MW for an air temperature of 77 deg. Fah. and in winter a temperature of −4 deg. Fah., when a continuous output of 7·5MW is maintained. The set was started up in October, 1954, and by September, 1955, it had completed 5000 service hours at an average load of 5MW. The average daily running time was about fifteen hours, and during the eleven month period of service the set was started up 300 times.

During the year under review the firm also negotiated a contract for the world's largest gas turbine power station, which will be set up at Edmonton, Alberta. It will consist of two 30MW two-shaft units, designed to operate on natural gas or heavy oil fuel, as required.

In Germany a number of gas turbine sets are under construction to the designs of the Baden works by the Brown-Boveri et Cie. Acktiengesellschaft, of Mannheim-Käfertal.

In the French works of Brown-Boveri et Cie. a set of 7·3MW is also under construction.

S.E.M.E.

We are informed by Alan Muntz and Co., of Hanworth Air Park, Browell's Lane, Middlesex, (the representative of the Société d'Etude Mecaniques et Energetiques (S.E.M.E.) of Rueil-Malmaison, France, and builder of that company's G.S. 75 free-piston gas generator) that the combined arrangement of a gas generator and gas turbine has during the period under review been increasingly adopted for a variety of uses. The number of G.S. 34 gas generators in service has now increased to seventy-five, and the total hours of operation to 150,000. The efficiency of a free-piston gas generator turbine set is the product of the efficiencies of the gas generator, the piping and the gas turbine. A typical efficiency obtained for a gas generator is 43 per cent, for the piping 98 per cent, and for the gas turbine 86 per cent, giving an overall efficiency of 36·2 per cent, corresponding to a specific fuel consumption of 0·392 lb per s.h.p. hour, which is of the same order as a diesel oil engine. Piston ring wear has been shown to be less than that of rings in diesel engine cylinders, and the use of chromium-plated rings is showing reduced wear.

During 1955 further free-piston engined minesweepers have been added to the French Navy and coasters of 850 tons constructed by Augustin Normand have given good results in North Sea service. The machinery for these coasters includes two gas generators feeding one gas turbine, which drives the propeller shaft through double reduction gearing. New electrical generating sets have been completed and commissioned for France,

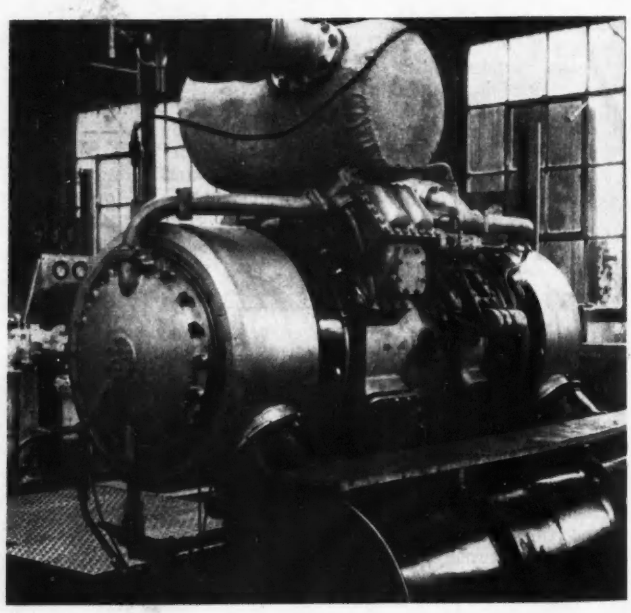


Fig. 8—Free-piston gas generator (" GS 75 ")

Corsica and North Africa. The satisfactory operation of gas generators on heavy fuel oils has been verified by the inspection of a generating set in Tunisia, which has now a record of 12,000 hours of operation. The gas turbine locomotive built by the Regie Nationale Renault, which is now in service on the Northern Lines of French Railways, continues to give good results. The gas generator is placed in the centre of the locomotive and it feeds a six-stage Rateau gas turbine which drives the four axles through two-stage reduction gear. Light fuel oil is used for the locomotive. During the year Alan Muntz and Co. developed the G.S. 75 gas generator for varied uses. The firm is now awaiting the arrival of the first 1000 h.p. G.S. 34, which, it is expected, will shortly be started up. In Fig. 8 we show the G.S. 75 gas generator.

(To be continued)

Coal in 1955

By the late SIR RICHARD A. S. REDMAYNE, K.C.B.

No. II—(*Concluded from page 63, January 13th*)

Cost of Production, Proceeds and Profit Per Ton on Saleable Coal

TABLE II gives the costs per ton and the profit earned per ton for the last quarter of 1954 and the first three-quarters of 1955. The rise in cost has been very considerable, due largely to the enhancement in wages and low production. Where a profit is shown it has only been obtained at an increase in the price of the coal. On the second quarter of 1955 there was a loss of 3s. 0·9d.

TABLE II—*Cost Per Ton of Production on Saleable Coal Proceeds and Profit or Loss Per Ton*

Quarter	Wages	Roof supports, general stores and repairs	Coal and power consumed	Other costs including depreciation	Total costs	Proceeds	Profit or loss
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
4th quarter, 1954	38 8·9	11 2·7	3 3·5	9 11·8	63 2·9	64 6·8	1 3·9
1st quarter, 1955	39 1·7	10 7·7	3 4·7	10 0·6	63 2·7	65 0·7	1 10·0 loss
2nd quarter, 1955	41 4·6	11 4·8	3 4·5	10 11·4	67 1·3	64 0·4	3 0·9 loss
3rd quarter, 1955	42 4·8	11 9·1	3 9·4	12 1·8	70 1·1	70 1·7	0·6

Items leading to the advancement in cost per ton were the introduction of a national day wage structure in April, 1955, estimated to cost £14,000,000 a year, the Yorkshire strike in May, causing a serious loss in output, the June railway strike, rising prices in steel supports, general stores and repairs. It is a fact worthy of notice that some pits in such, at present, unremunerative coal fields as Somerset and Forest of Dean, which were worked prior to nationalisation at a handsome profit, we are now informed are being worked at a loss. During the June quarter, 1955, we are told that the loss averaged 40s. 6d. a ton and in the Forest of Dean 31s. 8d.

Prices, Consumption and Quality of Coal

As from July 18th, the National Coal Board decided to raise coal prices by 10 per cent, or an average of 11s. 5d. per ton. This increase in coal prices meant that house coal would incur an increase ranging from 7s. 11d. to 19s. 1d. per ton, according to quality. It was estimated that fuel bills would be raised annually in consequence of the higher prices ruling in the case of private firms by £22,000,000, electricity £20,000,000, gas £17,750,000, and British Transport £8,700,000. One effect of this increase in the price of coal is an inevitable enhancement in the cost of light and power and all industrial commodities as well as railway freights and shipping. Indeed, as the National Union of Manufacturers said, this rise in the price of coal would result in "another twist in the rising spiral of all other prices" and would "force up prices to the detriment of our competitive power abroad and at the risk of a further round of wage increases at home." The prices of South Wales anthracites and "dry" steam coals supplied for domestic purposes as boiler fuel were increased by about 18s. 10d. per ton. Specimen retail prices (including the summer price reduction) which applied from July 10th were as follows Table III :—

TABLE III—*Specimen Coal Retail Prices*

	Quality Group 1*	3	5	7
	s. d.	s. d.	s. d.	s. d.
Northern Regions				
Glasgow and Edinburgh	158 11	129 5	107 0	85 9
Newcastle	149 1	119 7	97 2	75 11
Leeds and Sheffield	154 0	124 6	102 1	80 10
Liverpool	159 7	130 1	107 8	86 5
Manchester	159 0	129 6	107 1	85 10
Nottingham	149 3	119 9	97 4	76 1
Birmingham	159 9	130 3	107 10	86 7
Newport, Cardiff and Swansea	161 0	131 6	109 1	87 10
Southern Regions				
Ipswich	187 3	157 9	135 4	114 1
London	186 0	156 6	134 1	112 10
Brighton	191 8	162 2	139 9	118 6
Southampton	195 8	166 2	143 9	122 6
Bristol	177 7	148 1	125 8	104 5
Exeter	197 5	167 11	145 6	124 3

* Group 1 coal is available in very few towns.

The price of hard coke sold for domestic and industrial purposes were increased by amounts ranging from 18s. 4d. to 30s. 7d. a ton as from August 8, 1955. With regard to "industrial" coal, varying according to quality, the increased costs of the coal supplied would be : gas works, 12s. 5d.; power stations, 9s. 3d.; railways, 12s. 5d.; N.C.B. coking plants, 12s.; other coking plants, 11s. 8d.; iron and steel, 11s. 6d.; bunker coastwise, 11s. 9d.; bunkers, trawlers, 12s. 8d.; all other inland disposals, 10s. 11d.; Northern Ireland (other than house coals), 10s. 9d.*

The Association of British Chambers of Commerce, in a memorandum published on July 8th last, protested against the proposal to increase coal prices. The document was addressed to the chairman of the National Coal Board and the Minister of Fuel and Power, and asserted that "the coal mining industry was not contributing to any thing like a full measure to the national well-being."

In March last little worry was entertained as to the extent of fuel supplies then available, but there was concern about the forthcoming winter's position. Delegates to the September conference of the Association of British Chambers of Commerce at Sheffield estimated that another 6,200,000 tons of extra coal would be needed a year, and a spokesman of the Federation of British Industries, speaking on March 15th, stated that the prospective increase in industrial production in the next twelve months would require an additional 4,000,000 tons of coal.

The Minister of Fuel and Power, at a meeting in London on November 1st last, with the representatives of the National Production Advisory Council for Industry, stated that during 1955 for the first time we had to import more coal than we exported, at a cost of £80,000,000 in foreign exchange. He also stated that distributed coal stocks were higher than at the same time last year (1954), but there might be a severe winter and production of coal might not improve sufficiently, and it was not possible to increase coal imports without interfering with imports of iron ore for the steel industry. The Government had, therefore, made plans which would protect the most vital supplies—such as gas works, iron and steel plants, and railway and house coal by spreading any charge over the rest of industry.

Imports and Exports of Coal

As has already been stated, the total amount of coal imported during 1954 was, at the end of the year, according to National Coal Board's annual report, "just over 3,000,000 tons, the exact figure not being given." The Minister of Fuel and Power stated in the House of Commons on June 27th last that the approximate total amount of coal which would be imported during the year at rates then existing would be 12,000,000 tons. The Chancellor of the Exchequer, speaking to the Bankers and Merchants in the City of London on the night of Tuesday, October 4th, said that we had spent £47,000,000 on coal imports so far during 1955 against only £6,000,000 in 1954, that booming industry had used more coal, but the miners had produced less.

It is too early at the time of writing to make even an approximate estimate of the amount of the coal exported during the year, but it would seem clear from the information at present available that the figure of 13·6 million tons reached in the previous year (1954) will not have been achieved in 1955. For the Minister of Fuel and Power, speaking in the House of Commons on July 20th last, said that though exports of coal could not be reduced by more than about 2,000,000 tons, yet for 1956 the Government had decided to make a sharp reduction, which would mean a corresponding fall in our need for imported coal.

As *The Times*, in its leading article of July 20th last, said, "The next unwelcome fact is Britain cannot hope to produce a significant surplus of coal and thus recover its position

* In the Press of December 1st last, it was announced that summer prices of coal had ceased and that the prices per ton in London and the South of England had been advanced by 5s. ; graded becoming £9 8s and Grade 4 £7 7s 2d.

as a net exporter. There can be no point, therefore, in maintaining an export trade of 15,000,000 tons or so a year at the price of importing an equal amount—£1 a ton on balance."

Miners' Wages

Miners' wages are given in Table IV in respect of the last quarter of 1954 and the first three quarters of 1955, being the total average earnings of male workers of all ages at the collieries employed underground and at the surface. But the table does not give the average earnings of "detailed classes" of workers. For instance, workers "at the face" comprises several different classes of workers earning a different wage. There are a number of variants in respect of the kind of work performed underground, and the same is true of the surface workers also. The highest earnings made are by the men engaged in actually getting and filling the coal.

Table IV—*Average Earnings Per Man-Shift Worked and Wage Earned Per Week at Collieries Plus Value of Allowances in Kind Over the Last Quarter of* 1954 *and the First Three Quarters of* 1955

Quarter	Per manshift worked				Wage earned per week			
	At the face	All underground	Surface	All workers	At the face	All underground	Surface	All workers
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
4th quarter, 1954	60 10·5	52 2·5	35 9·2	48 6·9	299 9	273 5	207 6	260 0
1st quarter, 1955	61 7·5	52 8·1	36 0·5	49 0·2	304 4	277 8	212 4	264 6
2nd quarter, 1955	62 7·7	54 0·9	38 6·6	50 7·1	290 4	268 2	216 4	257 7
3rd quarter, 1955	63 10·4	54 10·8	38 8·6	51 3·2	269 5	250 5	202 1	240 11

On March 15th last an agreement was reached between the National Coal Board and the National Union of Mine Workers on the introduction of a new wage structure which included an increase of 11s. 6d. a week on the existing minimum rates for underground and surface day-wage men, which meant increases of at least 6s. a week for most of the 400,000 miners on time rates, and it was hoped to extend the new structure to piece-workers and similar employees within six months. It was expected that, subject to the approval thereof, the agreement was to take effect in the week commencing April 4th. The Board's estimate was that the cost of the increases would be about £13,000,000 a year and that coal prices would have to be raised. The new standard rates ranged from 27s. 9d. a shift to 31s. 9d. a shift for the five underground grades; from 24s. 5d. to 31s. 1d. for the five surface workers grades; from 30s. 5d. to 35s. 5d. for the three craftsmen grades underground, and from 27s. 1d. to 32s. 1d. for the three surface craftsmen and winding enginemen (the top surface grade).

On November 11th last, the leaders of the National Union of Mine Workers warned the National Coal Board that they were considering a new general wage claim and it was understood that the claim would be discussed by the union executive on December 8th. (South Wales miners had already suggested a claim for a further 30s. a week.) The miners, generally, are asking also for a series of improvements in conditions, including a third week's annual holiday with pay, a sick pay scheme, a shorter working week and the abolition of the "bonus shift" system. As to this latter, it will be remembered by those who have read the previous annual articles on coal in THE ENGINEER that the system was introduced with the object of discouraging voluntary absenteeism, a miner being paid for six shifts if he worked five in the week, but only for the shifts he had worked if they were lower than five. Alas, as far as one can determine the system has failed to secure a reduction in voluntary absenteeism. The miners are now asking that the present payment for six shifts be divided equally among the five and the men be paid for the number of shifts worked. It is possible—one would say probable—that a sick pay scheme and the consolidation of the bonus shift payment would encourage absenteeism. Another week's holiday, too, would mean the loss of about 4,500,000 tons of coal annually. The miners, too, desire a return to the seven-hour day.

On December 8th these claims were delivered to the Coal Board, which included £1 a week rise for 400,000 miners, the annual cost of which would amount to about £20,000,000, and add about 2s. per ton to the cost of coal. Further pay claims—to balance up—may be made for 300,000 piece-workers, which would amount to about £15,000,000 per annum, so further enhancing the cost of coal. The new wage claim, if granted, would mean the increase of the underground men's minimum from £8 6s. 6d. a week to £9 6s. 6d., and the surface men's from £7 6s. 6d. to £8 6s. 6d.

Manpower and Absenteeism

It is too early at the time of writing to give total and precise figures regarding absenteeism for the year 1955. But between May and September the number of persons employed fell from 707,000 to 701,200 and the miners worked less regularly during 1955 as compared with 1954. Up to the date given above, "voluntary" absenteeism had risen from 3·95 per cent to 4·11 per cent and "involuntary" from 8·20 per cent to 8·39 per cent. When giving these figures one is forced to ask how is the "involuntary" figure determined? The Coal Mining Organisation Committee, over which the writer presided in the year 1915–16, went thoroughly into this question and found that 5 per cent was a liberal allowance to make on all classes of colliery labour—surface and underground—for enforced absence from work due to sickness, injury and other unavoidable causes. On the 5 per cent basis the voluntary absenteeism for 1954 and 1955 would then be much higher than the figures quoted above. For July, 1955, the average for all sorts of absenteeism was 12·63 compared with 11·55 in July, 1954, the August and September figures being of the same order.

Strikes of Miners

Enthusiastic supporters of nationalisation of the coal mining industry prophesied that under that system the miners would work more peacefully and happily than heretofore, but such does not appear to have resulted—judging from the past year's record of unofficial strikes. The most important of these strikes was that in Yorkshire. On May 2nd last 26,000 miners from eleven pits were idle in support of 2600 men at the Armthorpe Colliery, who had been on strike for twelve days over a price list rates dispute, and who asserted that the piece rates schedules were out of date and demanded a revision. The National Coal Board refused to discuss the matter until the men returned to work. By May 8th the number on strike had increased to 87,000 and fifty-eight pits were laid idle in consequence. On May 4th a delegate conference of the whole of the Yorkshire Area of the N.U.M. voted for a resumption of work by an overwhelming majority and it was hoped that in consequence the miners might be persuaded to go back to work. Slowly they began to do so and by May 12th there were signs that the strike was collapsing. The net result was a grievous loss of coal and the beginning of negotiations with the Board which could have been undertaken without resorting to the strike.

Health and Safety in the Mines

As the annual report of the Chief Inspector of Mines for the year 1954 is not yet available, and that for the past year will not be forthcoming for some time, it is impossible to institute a complete annual comparison of results, but from such statistics as are available from other sources of information, it is possible to give figures regarding colliery accidents in respect of the second quarters of 1954 and 1955. The figures are shown in Table V.

In a report published on October 30th last by the Divisional Inspector of Mines for South Wales, on an explosion which occurred at Glyncorrwg Colliery, Glamorgan, on January 13, 1954, by which twenty-four miners were injured, the curious fact is revealed that the spark produced by the striking of a steel wedge by a steel hammer is capable of igniting methane. Tests made on the wedges in use were made after the accident to discover the igniting medium. The steel wedges of all the bars on the face were coated with rust, and the rusted wedges when in normal use became smeared with aluminium from the light alloy bars so as to produce a surface which, when struck by steel, gave sparks readily able to ignite methane.

Table V—*Fatalities as the Result of Accidents in Mines During* 1954 *and* 1955

	Killed during the thirteen weeks ended:		Seriously injured during the thirteen weeks ended:	
	June 26, 1954	June 25, 1955	June 26, 1954	June 25, 1955
Underground:				
Explosions of fire-damp or coal dust...	1	1	10	14
Falls of ground	41	49	162	158
Haulage	21	36	120	111
Miscellaneous (including shaft accidents)...	16	11	121	129
Total	79	97	413	412
Surface:				
All causes	10	18	53	43
Total: underground and surface...	89	115	466	455

Development of Mining Technique

One gathered from a perusal of the Reid Report, 1944, that technical development was a prospect which could easily permit of a larger output of coal being secured with a far smaller body of miners, but this promise has not been realised so far. Why not?

Technicians of the National Coal Board took part in a one-day conference on coal face mechanisation in London on July 27th last. The item of chief importance was that of power loading. At this conference Dr.

William Reid, a new member of the Board, stated that one man on a "power-loaded face" produced 1350 tons of coal, raised and weighed, per annum, as compared with some 740 tons on an "average face." In 1954 about 17,400,000 tons were produced by "power loading," against only 5,400,000 tons in 1948, and it was estimated that during 1955 some 22,000,000 tons would be power loaded, so on this trend, he thought, by 1957 the industry should produce by power loading 33,000,000 tons of coal, raised and weighed. Recently there has been introduced in the United States of America a method of breaking down coal by means of highly compressed air, which in some quarters is known by the name of "Airdot," a process which, one understands, is about to be tried experimentally at a colliery in Great Britain.

The European Coal Situation

On May 24th last, Monsieur Jean Monnet, chairman of the High Authority of the European Coal and Steel Pool, sent letters to the six participating Governments to the effect that he was willing to reconsider his decision to resign, and would be agreeable to serve for another term. But on June 1st last, the Foreign Ministers of the Community decided to nominate Monsieur René, whom the French Government had decided to nominate for the post. It was announced on May 10th last that the Foreign Secretary had appointed Mr. E. W. Meicklereid, who was Minister (Commercial) of the British Embassy in Paris, to be head of the United Kingdom delegation to the High Authority of the European Coal and Steel Community in succession to Sir Cecil Weir, who had relinquished his appointment which he had occupied since August, 1952, as he had agreed to serve as a part-time member of the British Transport Commission. On February 21st last the Minister of Housing and Local Government (Mr. Duncan Sandys) moved in the House of Commons "That this House approve the agreement concerning the relations between the United Kingdom and the European Coal and Steel Community, signed on December 21, 1954," and said that we asked to co-operate as fully as possible with the "Community" and that the agreement created convenient and effective machinery for constant exchange of information and consultation on matters of common interest regarding coal and steel, including production, estimates of future demand, exports, imports, technical developments and price policy, which would be of great value. But Britain was not committed to anything beyond the exchange of information and consultation. The motion was agreed to. On May 9th the Community celebrated the fifth anniversary of Monsieur Robert Schuman's announcement of his plan.

It was announced by the "Community" that, as from May 1st, frontier charges on international coal and iron ore railway freights would be cut throughout the Common Market. The remaining tolls on coal and iron ore, amounting to about one-third of the existing frontier charges, would disappear on May 1st, 1956. Hitherto trans-frontier traffic which accounted for 13 per cent of all community freight in coal, iron scrap and steel, had been on the average 25 per cent dearer than equivalent carriage in a single country. On January 20, 1955, the Council of Ministers endorsed the High Authority's proposals for "international through rates" to be established by stages between May 1, 1955, and May 1, 1957. Frontier charges on scrap and steel will be eliminated in two stages on May 1, 1956, and May 1, 1957. Charges amounting to about £6,000,000—a major obstacle to a freely working common market—will then have been removed. Frontier charges levied by the railway companies are based on the fiction that when a cargo crosses a frontier it starts its journey anew. It loses the benefit of the falling rate applied on all railways as the run grows longer, and must also pay heavy fees for imaginary terminal stations on either side of the frontier. These practices can add as much as 10s. a ton to the cost of freight every time a frontier is crossed. The railway companies are themselves lowering the freight rates in accordance with the Council of Ministers' agreement.

The High Authority had already eliminated "discriminations" in transport rates—that is, the tendency of each country to make the foreigner pay more for the carriage of goods than the home consumer. This question is of great economic importance for the proper working of the common market, and differentiation had always been a bone of contention between the Ruhr and Lorraine, the Lorraine steel industry feeling that it stood to gain and that of the Ruhr feeling that it stood to lose by these changes. It was stated in the Press on May 13th last that the High Authority had decided that sales of Ruhr coal should not be monopolised, as they had been hitherto, by a single central sales agency known as the "Georg," which should be replaced by a system which reconciled the need for competition on the Community's common market with the problem of maintaining stable employment in the Ruhr. Mr. Franz Etzel, vice-president of the High Authority, said that as the Ruhr produced half of the Community's 240 million tons of coal each year, the High Authority considered "Georg" to be a cartel able to determine prices and to control or restrict production or distribution on the common market. It therefore could not be allowed to continue its activities.

The new system proposed emphasised the independence of the six existing coal-selling agencies, none of which may in future contain more than the existing eight to eleven out of the Ruhr's fifty-five colliery companies. Each must have its own price list, its own sales policy and, after a transition period, its own selling agents, each having to apply for authorisation by the High Authority under the Community's anti-cartel code. I reproduce here a part of what appeared in a report in *The Times* of May 13th last: "The agencies may, however, organise sales in common for delivery to big consumers, such as railways, electric companies and gasworks, which buy more than 50,000 tons of coal a year and number about 1 per cent of buyers. Exports to countries outside the common market over which the High Authority exercises no control could also be sold jointly.

Georg, as the co-ordinating body, "may only maintain activities which do not restrict competition," such as publicity, technical research, market studies, and advice on general transport policy. "The change brought about by the new solution," said Mr. Etzel, "is profound and fundamental . . . It is not a masking over of the old organisation. . . . The High Authority hopes that it will permit competition to have happy effects on productivity and distribution . . . so that coal can be made a competitive source of power." Mr. Etzel emphasised that in future "the whole of the common market must be considered as a single market," and that no sales discrimination on a national basis would be permitted in any part of it. The coal cartel in Southern Germany, jointly organised by the Ruhr, Aachen, the Saar and Lorraine coalfields, and the sales organisations in the Saar, Belgium and France will be dealt with shortly.

This is the High Authority's first big step forward in its much-publicised anti-cartel policy. "The decision it is now about to take has long been considered vital for the future development of this policy and for the success of the community's efforts to free the common market of economic and political restrictions based on national producers' cartels."

On June 21st the European Coal and Steel Community Bill was published. By this Bill it is proposed to confer certain immunities and privileges on the delegation in the United Kingdom of the High Authority of the European Coal and Steel Community for when the agreement comes into force it will be administratively necessary for the High Authority to have a delegation in London. The Bill had already been read for the first time in the House of Commons.

It was reported in the Press of November 21st last that Britain was buying 12,000,000 tons of coal from the European Coal and Steel Community.

ZEUS and ZETR Reactors in Operation at Harwell

We learn that two new research reactors are operating at Harwell. They are ZEUS (Zero Energy Uranium System) and ZETR (Zero Energy Thermal Reactor), and are part of Britain's programme for studying different kinds of reactors. ZEUS is built to check the nuclear calculations on which the design of the fast reactor being built at Dounreay in the North of Scotland depends and in many essentials it is a full-scale model of the Dounreay reactor. A combined team from the industrial group of the U.K.A.E.A. and the Harwell research group working on ZEUS are gaining experience of the running of a fast reactor.

The cylindrical core of the ZEUS reactor, which is roughly 20in in diameter and 20in. long, is made up of uranium, which is very highly enriched in the 235 isotope (in ZEPHYR, the first fast reactor at Harwell the fuel is plutonium). The enriching of the uranium used in the core was carried out at the Atomic Energy Authority's factory at Capenhurst, near Chester. The core of ZEUS is surrounded by many tons of uranium in which plutonium is formed gradually as the pile runs. The amount of uranium 235 needed to permit the nuclear reaction to start was found to be very close to the predicted value.

The reactor is to be operated at a very low power level (100W) so that no cooling is required, although the rate of the nuclear reaction will be quite adequate for making all the necessary nuclear measurements; by comparison the design power for the Dounreay reactor is about 60MW.

ZETR uses a nuclear fuel in solution and is intended to provide information about the quantities of fuel which will be required for large-scale reactors using such solutions. Plutonium has already been studied in this reactor; uranium 235 is being studied now and uranium 233 is to be studied later this year. Natural water is used as a solvent at present, but in the summer heavy water is to be used.

It may be recalled that other reactors operating at Harwell are GLEEP (Graphite Low Energy Experimental Pile) and BEPO (British Experimental Pile), in which the fuel is natural uranium rods in graphite; ZEPHYR (Zero Energy Fast Reactor) with plutonium as fuel, in which it has been shown that two atoms of fissile material can be created for each one burned; and DIMPLE (Deuterium Moderated Pile Low Energy), in which the fuel is contained in heavy water. In addition, there are three other reactors under construction. These are DIDO and PLUTO, both powerful research tools, in which the fuel is contained in heavy water; and LIDO, a "swimming pool" type of reactor, in which the fuel elements are in a tank of ordinary water.

British Iron and Steel in 1955

THE rate of progress which has been so marked in the British iron and steel industry since the war continued throughout last year. It was a year in which more new plant came into full operation, and one which again emphasised the high level of efficiency which the industry has achieved. At the same time, the demand for British steel was such that the greater production capacity could not fulfil it, with the consequence that imports of steel in 1955 were higher than in the two preceding years.

Production and Supplies

At the beginning of last year it was estimated that home production of steel would amount to 19,500,000 ingot tons, compared with 18,520,000 tons in 1954. Actually, despite some dislocation created by the railway strike in June, the year's production totalled 19,791,000 tons, and thereby established a new record. Apart from the holiday months of July and August, and the "rail strike month" of June, the annual rate of steel production each month after January was above the 20,000,000-ton mark, the highest figure being achieved in November, when the annual output rate was 21,246,000 tons. The year's pig iron production amounted to 12,470,000 tons, compared with 11,883,000 tons in 1954. Commenting on last year's production, the British Iron and Steel Federation has stated that pig iron output per furnace is now 75 per cent higher than it was ten years ago, and that, similarly, steel output per open-hearth furnace is 75 per cent higher. In the same period, total steel output has shown, on the average, an annual increase of about 5·25 per cent.

As already mentioned, however, the increased home output of steel last year was not enough to meet the demand, with the result that there had to be higher imports. Although the precise figure of steel imports in 1955 is not yet available, it appears likely that it exceeded 1,750,000 tons. There were bigger imports of ingots and semis for further processing in this country, while users, who were assisted by the suspension of import duties, brought in larger quantities of finished steel, particularly sheets. Thus, according to an assessment made by the British Iron and Steel Federation, the total supply of steel in this country last year was 21,700,000 tons, an increase of 2,200,000 tons compared with 1954. The Federation says that, of last year's additional supplies, about 300,000 tons were added to exports as steel makers fulfilled the commitments entered into in the preceding year, but the greater part, roughly 2,000,000 ingot tons, was taken up in home deliveries. A small portion of the extra steel delivered to consumers and merchants went into stock, though it is unlikely that the additions to stocks were in any way disproportionate. A further quantity of steel, possibly about 200,000 ingot tons, was required last year to increase this country's exports of metal goods, and probably a similar amount went into additional supplies of private cars and durable consumer goods for the home market. There seems little doubt, however, that a large part of the extra steel delivered to home users last year went into the production of capital equipment for British industry. Incidentally, it has been stated that the aggregate increase in home steel consumption during the past two years has been of the order of 15 per cent, while the rise in metal goods production has been over 20 per cent.

Raw Materials

Although new plant and increasing efficiency in the British steel industry were again significant factors in last year's operations, the bigger output of iron and steel could not have been achieved without increased supplies of raw materials. On account of the low iron content of most of the home-produced ore, dependence upon imported ores is inevitable, and in the earlier part of last year there was undoubtedly concern as to whether ore supplies from overseas could be maintained at a rate sufficient to meet the demand. But, fortunately, the situation improved and before the end of the year ore imports were averaging about 1,200,000 tons a month. Ore transport from overseas sources of supply is a matter which created anxiety at different times last year, because of the calls on shipping for the big imports of coal to this country. In the iron and steel industry's second development plan, the matter has been given attention, for the plan notes that the industry has made arrangements for the building of nineteen specially designed ore carriers. Twelve of them, each of 8500 tons capacity, are being designed especially for the shallower ports, such as Port Talbot, Barrow and Workington, and the remaining seven carriers are each of 13,500 tons capacity.

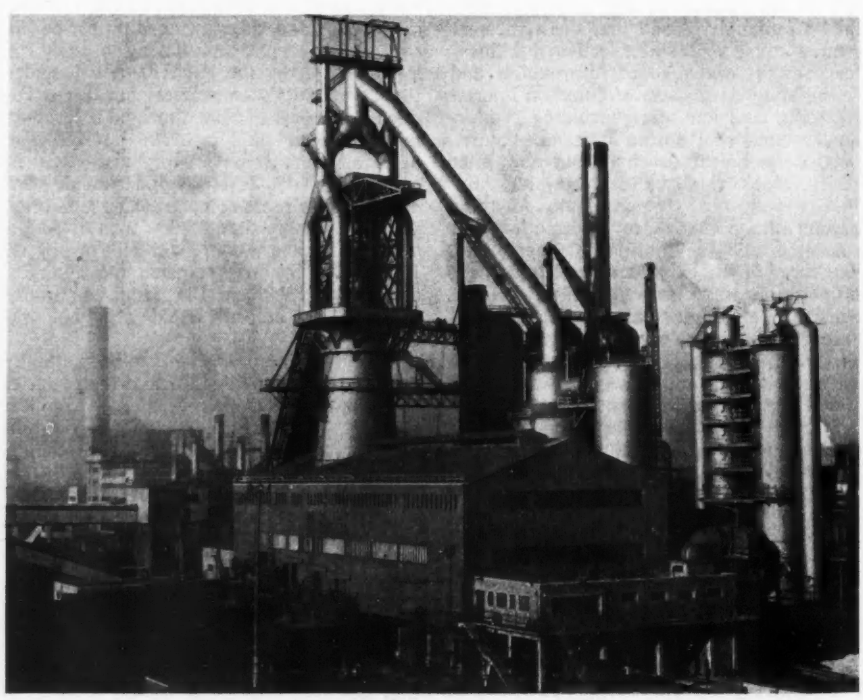
The home output of iron ore last year was probably round about 13,000,000 tons. Iron ore production in this country, however, is approaching a point at which open-cast mining is dwindling. An extension of underground ore mining will mean greater expenditure, and another difficulty which is being experienced is the shortage of labour and housing accommodation in the ore mining areas.

Supplies of coking coal last year do not seem to have presented any great difficulty to the iron and steel industry, despite the general shortage of coal. Over the first ten months of last year, the iron and steel industry's coal consumption averaged 385,600 tons a week, compared with 390,300 tons a week in 1954. This indicates the progress in fuel efficiency which the iron and steel industry continues to make. The total quantity of coal (including the coal equivalent of oil) required to produce a ton of finished steel has fallen since 1947 from 40·4 cwt to rather less than 34 cwt. There are several ways in which this economy has been achieved. On the blast furnace side, for example, the increasing use of sinter, as well as economising iron ore consumption, has also helped to save fuel, for sinter has a higher iron content than the ore from which it is made, while its physical structure is conducive to the maximum blast furnace efficiency.

As to iron and steel scrap, there was a notable increase in the quantity obtained from abroad last year. Between January and November, imports of scrap averaged 106,800 tons a month, against 65,000 tons in the comparable period of 1954. The growth of steel production in other countries which used to export scrap has meant a considerable change in the overseas sources of supply. In 1954, the scrap imported into Great Britain came from about thirty different countries and in the past twelve months that number has most likely increased. The steel industry's aim is to get scrap consumption to a level which can be met from home supplies. Last year those supplies were reasonably good, though it is evident that there can be no relaxation of the efforts that continue to be made to obtain larger tonnages of good quality scrap from home sources, in addition to the quantities regularly arising in the steel works themselves.

Iron and Steel Prices

In December, 1954, the Iron and Steel Board determined new maximum prices for iron and steel products, following a general review of the level and structure of those prices. The increase, including interim



The No. 4 blast furnace at the Margam works. Its hearth diameter is 29ft 9in and its iron-making capacity exceeds 10,000 tons a week. The slag pits are shown on the left of the illustration and the gas cleaning plant in the right foreground

increases made while the review was in progress, represented an addition of about 3 per cent to the prices ruling at the beginning of 1954. The Board pointed out that in its review it had followed the general principle of determining maximum prices by reference to cost of production and margins for depreciation and profit.

Last year, the principal price increases affecting all iron and steel products were made on July 25th. These increases were not a uniform addition to existing maximum prices, ranging from 9½ per cent on foundry pig iron and 7 per cent on basic pig iron to 5¾ per cent on heavy steel products. When announcing these increases, the Iron and Steel Board pointed out that production costs had risen, notably on account of the higher price of coal, an increase in the cost of imported materials, the increase in railway rates announced last May, and the general wage increases negotiated within the iron and steel industry earlier last year. The Board went on to say that although, as a result of increased production and efficiency, it was possible for the industry to absorb some part of the increases in cost, the greater part must be reflected in the prices of iron and steel products if the industry's objectives were to be maintained. The Board added that the new prices were approximately 15 per cent below American and Continental iron and steel prices.

In November, the Iron and Steel Board announced some increases, for the most part small ones, in the maximum prices of a limited number of products " to put on to an economic basis steels which demand special care in production or involve high rolling costs." On December 19th, increases were made in the prices of basic and hematite pig iron, and low phosphorus and Scotch foundry iron. These changes, it was stated, were necessary " to take some account of the higher cost of ore, in particular the increase in the cost of ocean freight of imported ore." The Iron and Steel Board said then that no changes were at present being made in the maximum prices of steel products.

The Development Programme

It has been estimated that in the last ten years the British iron and steel industry has spent on the average over £1,000,000 a week on modernisation and development. At present, the industry's capital expenditure is about £80,000,000 a year. Work on the schemes detailed in the second post-war development programme continued apace throughout last year. Particulars of the schemes and a general assessment of the iron and steel industry's present and future developments were published last February in a report entitled *Development of the Iron and Steel Industry, 1953 to 1958*, which was prepared by the Iron and Steel Board.

This second development plan was based on an annual pig iron output of 15,150,000 tons and an annual crude steel production of 22,200,000 tons by the year 1958. As was stated in the report, the main technical factor of the prospective developments in steel-making is an increase in the use of molten pig iron in the charge for open-hearth furnaces. The relatively high yield of the tilting furnace process, assisted by the contribution from the iron ore charged into the furnace, tends to compensate for the lower fuel and capital costs of the Bessemer process. The economic balance varies, however, according to local conditions, and in suitable cases there may be an increase in the output of Bessemer steel. The average size of fixed open-hearth furnaces, generally used where the proportion of scrap in the charge is more than about 40 per cent, or the phosphorus content of the pig iron is not too high, has increased substantially in recent years. The trend towards the use of bigger furnaces, both fixed and tilting, will continue.

The development projects which are now in progress are to a considerable extent concerned with the replacement of existing plant and will undoubtedly lead to a further increase in productivity. The total cost of the schemes so far approved under the 1953–58 plan is put at just over £250 million (at 1955 prices). Other projects to be approved under the plan will most likely raise the total expenditure in the five-year period to £300 million. Last year, some of the extension and modernisation projects were completed, work on others was well advanced, and some of the projects detailed in the development plan were started.

Plant Extensions

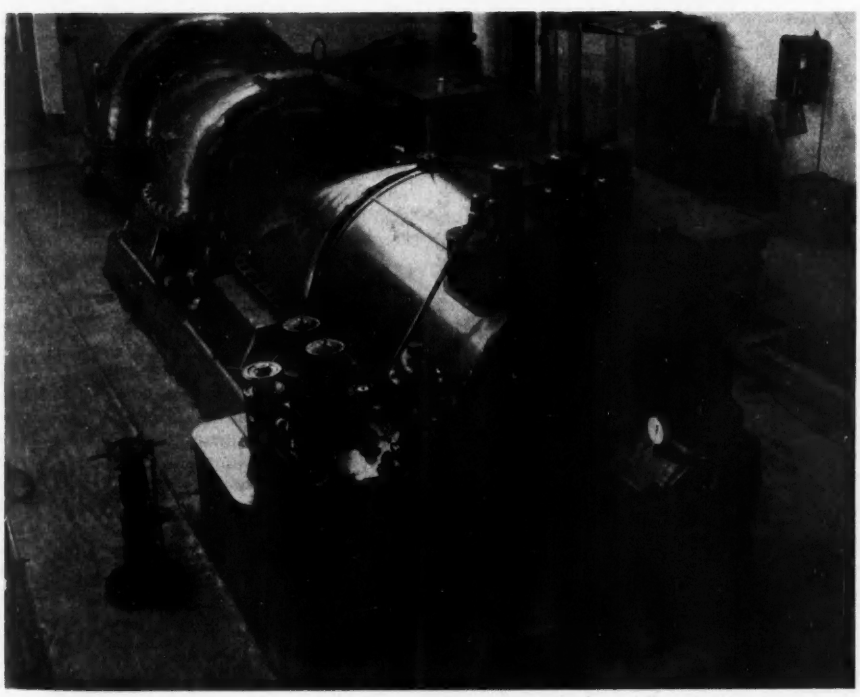
We give here particulars of some of the work accomplished during 1955 under the iron and steel industry's programme of development and expansion. In South Wales, at the Margam works of The Steel Company of Wales, Ltd., a fourth blast furnace was started up at the beginning of last week. The building of this furnace is the principal item in the second stage of the company's development programme. Other items include the installation of a sinter plant, and the erection of ninety additional coke ovens and a by-product plant at Margam, and an extension to the melting shop together with new annealing capacity at the Abbey works. These extensions are designed to bring the company's pig iron output up to 1,450,000 tons a year and steel ingot production up to 2,400,000 tons a year.

The No. 4 blast furnace, which is illustrated herewith, has a hearth diameter of 29ft 9in and is consequently the biggest furnace operating in Europe ; its iron-making capacity is more than 10,000 tons a week. The furnace is situated on the south-west side of the Margam works and has its own stockyard which can take 150,000 tons of ore. Iron ore from the wharf and from the home ore tippler reaches this stockyard by overhead conveyor and is distributed by a stocking out bridge. A reclaiming bridge is provided to lift the ore from stock and to deposit it on to a conveyor system which carries it to the bunkers.

The No. 4 furnace, which is 242ft high, is similar in construction to Nos. 2 and 3 furnaces, although on a larger scale. As mentioned above, its hearth diameter is 29ft 9in and the diameter of the bosh is 33ft ; there are twenty-one tuyeres. In the early stages of the construction of the furnace, a certain amount of difficulty was encountered owing to the nature of the substrata. Owing to the predominance of clay in the gravel bed it was difficult to obtain a satisfactory set for the concrete piles ; to overcome this liquid cement was pumped into the gravel, after which 445 piles were driven to support the 75ft diameter foundation block.

Air for the furnace is supplied by an axial-flow turbo-blower, built by the Oerlikon Company, with a capacity of 125,000 cubic feet a minute. The blower is shown in our second illustration. To preheat the air there are three stoves, each 140ft high, the control of which is fully automatic. The stove attendant is able to supervise the sequence of operations from a desk in the control room. The slag from the new blast furnace is run straight into pits alongside, where it is mechanically loaded into heavy road vehicles for transport to the tips. As well as the ninety new coke ovens at Margam, additional coke oven batteries have been completed by Guest Keen Iron and Steel Company, Ltd., at Cardiff, and by Richard Thomas and Baldwins, Ltd., at Ebbw Vale. At the finishing end of the South Wales steel industry, a new five-stand cold reduction mill has been built at Ebbw Vale by Richard Thomas and Baldwins, Ltd. The tinplate mill being constructed by The Steel Company of Wales, Ltd., at Velindre, is now getting near to completion.

One of the art plates included in our last issue contained an illustration of the extension to the coke oven plant of The Stanton



The turbo-blower which provides air for the No. 4 blast furnace at Margam works. It is claimed to be the first steam-driven axial-flow turbo-blower to be used in this country, and has a capacity of 125,000 cubic feet of air per minute

Ironworks Company, Ltd., near Nottingham, which was completed last year. This plant is virtually a duplication of a battery of forty-one W-D Becker combination regenerative ovens built in 1939. The capacity of each of the original ovens is 14·5 tons of coal, with a moisture content of 9 per cent ; until eighteen months or so ago, these ovens were under-fired by coke oven gas, but since then clean blast furnace gas has been used. This changeover was made to bring the original ovens into line with the new No. 2 battery. This battery consists of forty-four ovens, similar in construction to those in the No. 1 battery. The daily carbonising capacity of both sets of ovens is 1900 tons of coal. In addition to the No. 2 coke oven battery, The Stanton Ironworks Company, Ltd., has installed blast furnace gas cleaning equipment and by-products recovery plant. The increase in the company's coke output is such that its pig iron production is expected to rise from 350,000 tons to 400,000 tons a year.

Another impressive programme within the scope of the steel industry's second development plan is that which is being undertaken at the various works of The United Steel Companies, Ltd. It may be recalled that most of the "Seraphim" project, at the Appleby-Frodingham works at Scunthorpe, has been operating since the latter part of 1954. Last September, further schemes, likely to cost over £1,500,000, were announced for the Appleby-Frodingham works. These schemes include the installation of another turbo-blower, an additional open-hearth furnace and its ancillary equipment, and an ingot stocking, handling and loading gantry. Foundation work for the new turbo-blower was started last autumn ; the blower will be capable of delivering 150,000 cubic feet of air a minute to the blast furnaces at a pressure of 35 lb per square inch. The new open-hearth furnace will be the third in the Frodingham melting shop, It will produce about 120,000 tons of steel annually and, like the turbo-blower, is expected to come into operation some time next year.

At the Rotherham works of the Steel, Peech and Tozer branch of the United Steel Companies, Ltd., a new railway axle forge and a ring rolling plant were completed last summer. A full description of these plants was given in THE ENGINEER of July 1, 1955. At the same works, later in the year, site work was started for the erection of a continuous medium strip mill. This plant, to be known as the Brinsworth mill, is expected to cost £3,600,000 ; it is being designed to produce strip from 4in to 18in wide, with a maximum thickness of 0·25in down to 0·042in minimum in deep drawing, mild, medium carbon, razor and stainless quality steels.

Another "United Steel" project is the installation of a combination bar and continuous rod mill at the Stocksbridge works of Samuel Fox and Co., Ltd. This mill, which is being supplied by the Brightside Foundry and Engineering Company, Ltd., will roll bars and rods in alloy, high carbon and stainless steels from 0·212in to 2·5in diameter and equivalent sizes in squares and other sections. Yet another project which was put in hand at the Stocksbridge works towards the end of last year is the installation of a 20ft diameter electric arc furnace for the production of special steels. Side by side with this installation, the billet mill is to be reconstructed. The reconstruction includes the addition of two 32in, two-high reversing mills.

Finally, the development programme of the United Steel Companies, Ltd., includes the modernisation of the rolling mills at the Workington Iron and Steel Company, in Cumberland.

In our last issue, we illustrated in Plate 1 the two 27ft 6in hearth diameter blast furnaces which are now nearing completion at the Cleveland works of Dorman, Long and Co., Ltd., Middlesbrough. These furnaces, together with a new coke-oven battery, are to come into production this summer, and have been designed to increase the company's basic iron-making resources by 286,000 tons a year, and bring its total coal carbonising capacity up to 2,400,000 tons a year. The blast furnaces and coke ovens are part of the third stage of the Dorman Long development programme. This stage includes also the erection of a medium section mill and a blooming mill at the Cleveland works, and the building of a combined universal beam and heavy section mill on the Lackenby site. It is expected that the Cleveland blooming mill and medium section mill will be finished this year. The building, 3000ft in length, which is to house the universal beam and heavy section mill and also a billet mill, at Lackenby, is making good progress and before the end of last year parts of the mill equipment were being installed. At Dorman Long's Redcar works a new hot slab shear was installed last year, while at the Clarence chemical works a benzole refining plant and a tar distillation plant are nearly ready to start operation.

Another development on the North-East Coast which was completed last year is the steel pipe plant which was officially opened at the end of November by the South Durham Steel and Iron Company, Ltd., Stockton-on-Tees. This plant has been designed to manufacture steel pipes from 16in to 40in in diameter, in lengths up to 40ft and from ¼in to ⅜in in plate thickness.

In Scotland, the steel industry's development plan, work on which progressed throughout the year, includes the building of a new blast furnace and coke ovens and also the erection of a melting shop by Colvilles, Ltd. These works are proceeding at Ravenscraig, Motherwell, on a site adjacent to the company's Lanarkshire and Dalzell works. This project, the whole of which will cost about £20,000,000, is rather more than one-third of the way to completion. It is hoped that the blast furnace, which will produce 350,000 tons of pig iron a year, and the melting shop, with a capacity of 400,000 tons a year, will be ready for work in the latter half of 1957.

CONCLUSION

It will be seen from this general review of the British iron and steel industry that efforts to improve the industry's efficiency still further continue to be made, and that during 1955 there was no slackening of the rate of development. The schemes to which we have all too briefly referred by no means exhaust the list of those which are in hand ; they do, however, present a general picture of the kind of projects that are being carried out in all the iron and steel-making areas of Great Britain.

Naval Construction in 1955

By RAYMOND V. B. BLACKMAN

No. III—(*Continued from page 72, January 13th*)

AUSTRALIA

H.M.A.S. "MELBOURNE," the second aircraft carrier for the Royal Australian Navy, was completed on November 8, 1955 at the Barrow-in-Furness shipyard of Vickers-Armstrongs, Ltd. This light fleet aircraft carrier was laid down as H.M.S. "Majestic" on April 15, 1943, and launched on February 28, 1945, but after the war her completion date was repeatedly postponed owing to a series of constructional delays occasioned by successive modifications and improvements in design which latterly included the fitting of the angled deck, the installation of one of the new steam catapults, and the provision of all the latest devices introduced into ships of her kind. According to officially revised figures issued recently she has an increased overall length of 702ft with a length between perpendiculars of 630ft and a waterline beam of 80ft. Her displacement has turned out at 15,700 tons standard and about 20,000 tons full load, while she has an overall width of 128ft and a draught of 25ft. Her armament comprises twenty-five 40mm anti-aircraft guns. Four Admiralty three-drum boilers and two sets of Parsons single-reduction geared turbines, turning two screws and developing 42,000 s.h.p., give her a designed speed of 24·5 knots.

Of the three "V" class super-destroyers or fleet escort ships being built in Australia two have been launched and one is nearing completion. Two are under construction at the Cockatoo Island Dockyard, Sydney, of which the "Voyager" was begun on October 10, 1949, and launched on March 1, 1952, being in an advanced stage at the end of 1955, while the "Vendetta," begun in March, 1952, was launched on May 3, 1954. The "Vampire" was begun by H.M.A. Naval Dockyard, Williamstown, on July 4, 1949. These vessels, the largest of the destroyer type ever built in Australia, will be basically similar to the "Daring" class built in Great Britain for the Royal Navy, but the design has been modified to suit Australian conditions. With a displacement of 2610 tons standard and 3700 tons full load, they have a length of 390ft overall, a beam of 43ft and a draught of 12ft 9in and they will be armed with six 4·5in guns, six 40mm A.A. guns, ten 21in torpedo tubes, and the squid triple-barrelled anti-submarine, mortar. Two boilers and two sets of Parsons geared turbines of 54,000 s.h.p. were designed to give them a speed of 34·75 knots.

Four new fast anti-submarine frigates are being built in Australian yards, two at Cockatoo Island, Sydney, New South Wales, and two at Williamstown, Melbourne, Victoria. Although these ships are designated anti-submarine frigates, they will actually be more like destroyers in which the capacity for anti-submarine warfare has been the principal factor in determining the provision of weapons and equipment. With a displacement of 2000 tons standard and 2800 tons full load, they will have a length of 360ft between perpendiculars and 370ft overall, a beam of 41ft and a draught of 12ft. The armament will comprise two 4·5in dual-purpose guns, two 40mm anti-aircraft guns, twelve 21in torpedo tubes, and two limbo three-barrelled anti-submarine mortars. The propelling machinery comprises two Babcock boilers and geared turbines of 30,000 s.h.p., turning two screws equal to a speed of 30 knots.

Of the four "Q" class destroyers scheduled for full conversion into fast anti-submarine

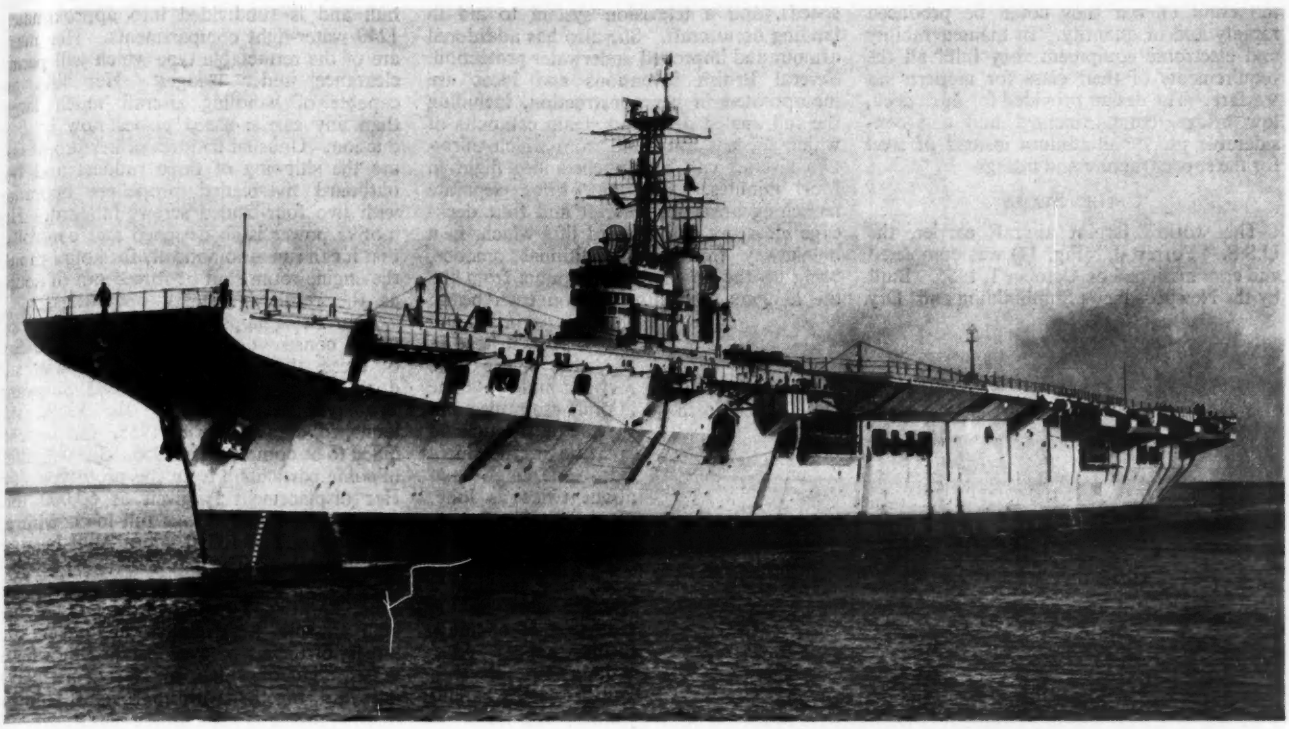


Fig. 14—"Melbourne," new Australian aircraft carrier with angled deck and steam catapult. Completed and renamed October 28, 1955

frigates in Australia the "Quadrant" and the "Queenborough" (Fig. 15) have been commissioned, and the "Quickmatch" was completed at the end of the year. The "Quiberon" is being converted at Garden Island, Sydney, and should be completed by the middle of 1956. These ships are generally similar to the first-rate frigates fully converted from destroyers in the Royal Navy, but they differ in several features from the British fast anti-submarine frigates and from each other. A new boom defence vessel, the "Kimbla," built at Maryborough, Queensland, was completed by the end of the year.

Canada

The light fleet aircraft carrier "Bonaventure" is nearing completion at the Belfast yard of Harland and Wolff, Ltd., where she was laid down on November 27, 1943, and launched as H.M.S. "Powerful" on February 27, 1945. Her construction was stopped in May, 1946, and she was laid up until it was announced on July 25, 1952, that the ship which had been suspended for over six years had been purchased by Canada for completion by her original builders, and she was renamed. Before constructional work on the carrier was resumed, however, she was redesigned to handle jet aircraft, the modifications including the strengthening of the flight deck and elevators, improvements in deck arrester gear, and the installation of the new steam catapult capable of shooting heavy aircraft into the air at the rate of 100 knots. Plans were again revised subsequently to provide for a completely modern aircraft carrier embodying the angled deck arrangement and the new mirror landing sight. After her reconstruction and modernisation she will have an increased length of 700ft with a displacement of about 16,000 tons standard and over 20,000 tons full load. Four Admiralty three-drum boilers and two sets of Parsons single reduction geared turbines, at which the steam pressure will be 350 lb per square inch, will develop 42,000 s.h.p., equal to a maximum speed of 25 knots.

H.M.C.S. "St. Laurent" (Fig. 16), the first of the Royal Canadian Navy's new anti-submarine destroyer escorts, all-Canadian designed and built, and developed as a counter to the modern, fast submarine, began her builders' trials on August 15, 1955, and was commissioned on October 29th. Built at the Montreal shipyard of Canadian Vickers, Ltd., where she was laid down on November 22, 1950, and launched on November 30, 1951, she is the prototype of fourteen ships of her class all built in Canadian shipyards, the other vessels being the "Skeena," "Fraser," "Kootenay" and "Columbia," by the Burrard Dry Dock and Shipbuilding Company, Ltd., North Vancouver; the "Saguenay," "Margaree" and "Chaudierre" by Halifax Shipyards, Ltd.; the "Ottawa" and "Restigouche" by Canadian Vickers, Ltd., Montreal; the "Assiniboine" and "St. Croix" by Marine Industries, Ltd., Sorel, Quebec; the "Gatineau" by Davie Shipbuilding and Repairing Company, Ltd., Luazon, P.Q., and the "Terra Nova," by Victoria Machinery Depot Company, Ltd., B.C. With a displacement of 2000 tons standard and 2600 tons full load, all these vessels have a length of 366ft, a beam of 42ft and a draught of 12ft 9in. The armament comprises four 3in anti-aircraft guns in twin mountings, two single 40mm A.A. guns and two ahead projecting improved triple-barrelled anti-submarine mortars. The main propelling machinery consists of two water-tube boilers and a two-shaft arrangement of geared turbines designed for a speed of 27 knots. The main engines of the "St. Laurent" were supplied by Yarrow and Co., Ltd., Scotstoun, Glasgow, and installed by Canadian Vickers, Ltd., Montreal. The main turbines and condensers are of English Electric Company's design. The remaining thirteen ships will have similar propelling machinery of British design, but manufactured in Canada. They are officially classed as major warships and as such they are the first to be designed completely in Canada. They are intended primarily for the detection and destruction of modern fast submarines, for which purpose they have long-range Asdic gear to probe for underwater craft, and improved armament. Their design was worked out with assistance from the British Navy and the United States Navy so that in

Fig. 15—H.M.A.S. "Queenborough," Australian destroyer converted into a fast anti-submarine frigate

the event of war they could be produced rapidly and in quantity. In manœuvrability and electronic equipment they fulfil all the requirements of their class for modern sea warfare. The design provided for flush deck, low bridge, compartmented hull and considerable use of aluminium instead of steel for the superstructure and fittings.

United States

The world's largest aircraft carrier, the U.S.S. "Forrestal," (Fig. 17) was completed and commissioned on October 1, 1955. Built by the Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia, she was laid down on July 14, 1952, and launched as recently as December 11, 1954, so her completion already is a notable achievement for so large and complicated a ship and for a prototype. With a standard displacement of 59,650 tons and a full load displacement of 75,900 tons, she will have a length of 990ft between perpendiculars and 1036ft overall, a water-line beam of 129ft 6in, an extreme width of 252ft, and a maximum draught of 37ft. Her main propelling machinery comprises four sets of geared turbines manufactured by the Westinghouse Electric Corporation, turning four shafts and developing 260,000 s.h.p., equal to a speed of 33 knots, the engines being fed by eight Babcock and Wilcox boilers. The ship was designed to carry and operate ninety to 100 aircraft, according to size and type, and to accommodate 3826 personnel (466 officers and 3360 men). She has a main armament of eight 5in, 54-calibre dual purpose guns disposed in single mountings on sponsons, two on each side forward and two on each side aft. As originally projected she was to have been flush decked with a retractable bridge, but as redesigned she has the standard fixed island superstructure on the starboard side which the provision of the angled deck allows. She is the world's largest warship and the biggest aircraft carrier ever built. The design of this great floating and highly mobile bomber and fighter base called for a runway considerably longer than that provided by the flight deck of the largest existing aircraft carriers, to operate larger, faster and heavier carrier-borne naval aircraft of the newest designs from her decks. As compared with her predecessors, she has greater catapult launching power, increased arresting capacity, larger elevators and higher hangar decks with a head-room of 25ft to accommodate the high tails of aircraft with supersonic speeds, and a television system to aid in landing on aircraft. She also has additional armour and improved underwater protection. Several British inventions and ideas are incorporated in her construction, including the full angled deck and steam catapults of which she has four, and from which thirty-two aircraft can be launched into flight in four minutes. She has three separate launching areas for aircraft and four deck-edge elevators or outboard lifts which, in a breakaway from the traditional practice, bring up the bombers and fighters from the the hangars amidships and on each beam, three to starboard and one to port, instead of on the centre line forward and aft. The aircraft are pulled out by tractor through an aperture in the ship's side, 26ft high and about twice as long. Contrary to former constructional method, her flight deck, built of steel, has become a strength deck by the reduction of openings in the hangar sides. Falling into line with British carrier architecture, the bow is enclosed up to the flight deck to give better seaworthiness in all kinds of weather. On the starboard side of her flight deck the new carrier has a very large sponson jutting outboard over the sea from the control island superstructure for use as an additional parking area. The actual total area of her flight deck is nearly 4 acres. The ship was designed to carry atom bombers as well as jet fighters and reconnaissance aircraft. Her rapid-firing 5in guns give her greater fire power than any of the previous carriers, her gun turrets are automatically controlled and operated from another part of the ship, and she has large rooms for decontaminating personnel in the event of atomic attack. She has a much strengthened underwater hull and is subdivided into approximately 1240 water-tight compartments. Her masts are of the retractable type which will permit clearance under bridges. Her lifts are capable of handling aircraft much larger than any carrier-based planes now in production. Unusual features of her propulsion are the shipping of three rudders and two outboard five-bladed propellers operating with two four-bladed screws inboard. Her motive power is so designed and controlled that it can run automatically for hours should the engine-room staff be forced out of action as the result of enemy operations.

Fig. 16—H.M.C.S. "St Laurent," first of fourteen new destroyer escorts building in Canada. On trials 1955

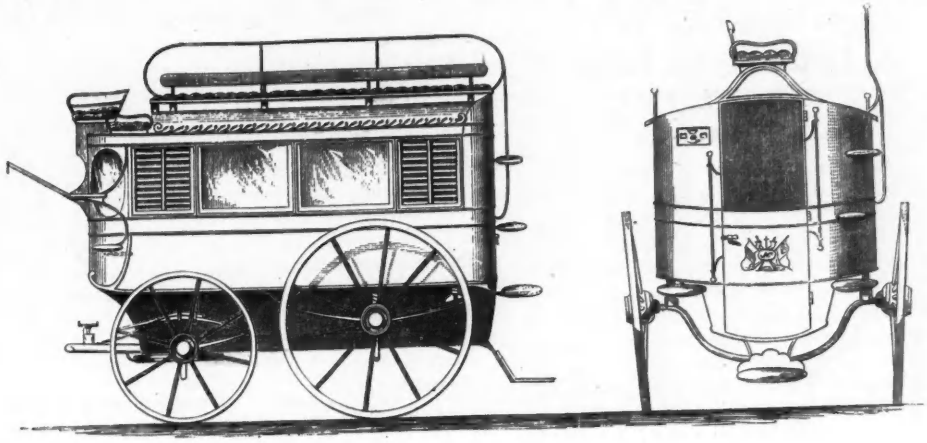
Four sister ships of the "Forrestal" are under construction or projected. The first of these, the "Saratoga," which was laid down at the New York Naval Shipyard, Brooklyn, on December 16, 1952, was launched on October 8, 1955, and is scheduled to be completed in 1956. She will differ in some particulars from the prototype ship. Her displacement is given as 60,000 tons standard and 76,000 tons full load, with an overall length of 1039ft and a 239ft beam at her flight deck. The main difference between the two carriers will be in the steam plant. The "Saratoga" will have the latest design high pressure, high temperature boilers, the largest of their type ever installed in a naval vessel, eight of which, by New York Naval Shipyard, together with improvements in the main propelling machinery arrangements, are expected to deliver even more power than the installation in her predecessor, calculated to produce a higher speed in the region of 35 knots. The third ship of the class, the "Ranger," was laid down by the Newport News Shipbuilding and Dry Dock Company on August 2, 1954, and by the end of 1955 she was in an advanced stage of construction. She will have General Electric Company geared turbines like the "Saratoga" and Babcock and Wilcox boilers like the "Forrestal." The fourth ship of the class, the "Independence," was begun on June 30, 1955, by the New York Naval Shipyard, Brooklyn; and the contract to build the fifth ship, which will probably be named "Kitty Hawk," also of 60,000 tons standard displacement, was awarded to the New York Shipbuilding Corporation, Camden, New Jersey, on October 26, 1955.

(*To be continued*)

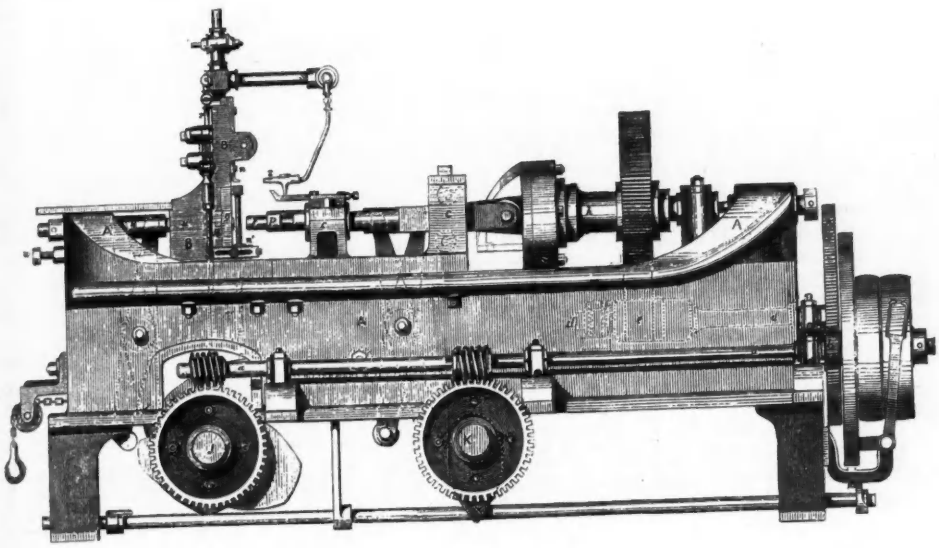
Fig. 17—U.S.S. "Forrestal," the largest aircraft carrier ever built in the world. Commissioned October 1, 1955

Engravings of 1856

In our Centenary Number there are included some reproductions of wood engravings which were printed in early volumes of THE ENGINEER. Throughout the remainder of this year it is our intention to publish further selections of these reproductions. Those printed here are selected from the wood engravings which appeared in the first two volumes of THE ENGINEER in 1856.

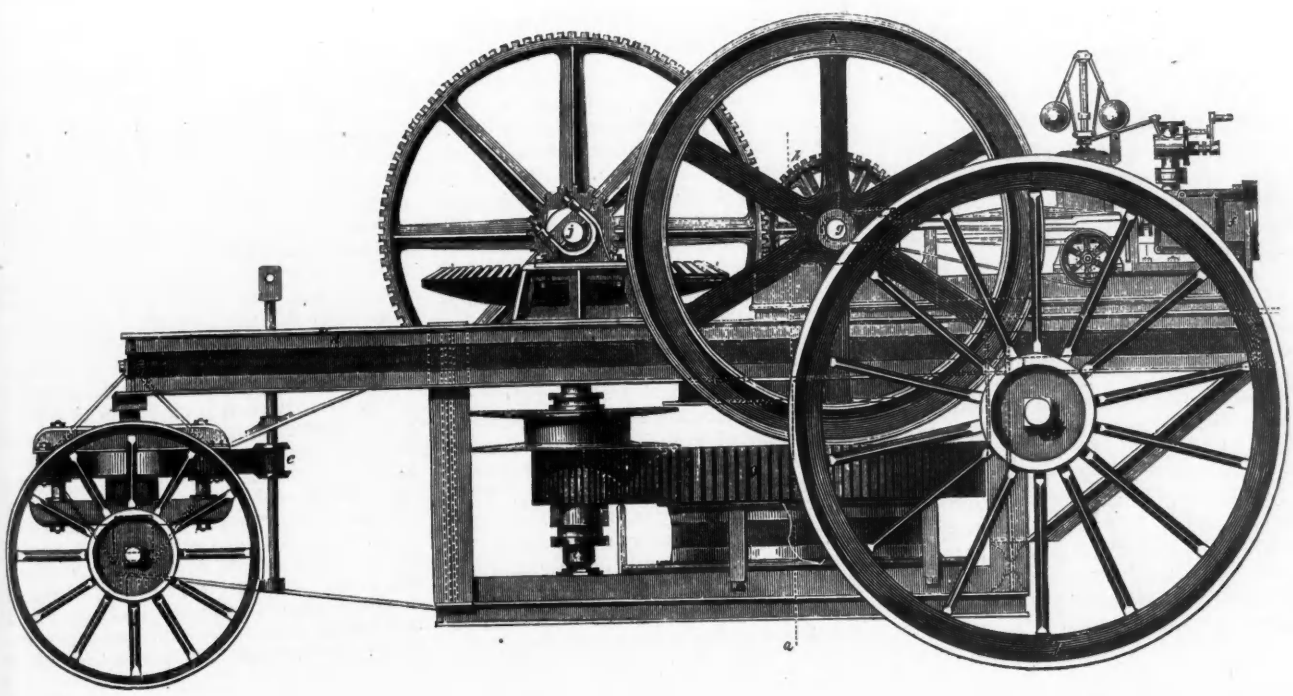


The illustration above shows the design of "Miller's Improved Omnibus," for which the London General Omnibus Company awarded a prize of £100. Among the improvements claimed were that the "lower body" was carried down 4in lower than usual, thus giving more room for the legs, and the roof was raised 10in along the centre "to allow a person entering the omnibus to walk upright with his hat on."



Mr. Joseph Haley's riveting machine, shown in the engraving on the left, was "discovered" during a visit in 1856 to the works of Messrs. Galloway, in Manchester. The machine was adapted for rivets, from ¾in to 1in diameter, and it was claimed that "of the ordinary boiler rivets, upwards of 30 cwt per day could be turned off from one machine," the usual speed being about forty strokes a minute.

Below there is reproduced an engraving of "Fowler's Machinery for Ploughing Land." To supply the machine with steam, it was explained, "a boiler is used, which is mounted on wheels by itself; it is coupled to the machine, and has a flexible pipe for conducting the steam to the cylinder."



LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A NEW INSTITUTION ?

SIR,—To meet the increasing national demand for engineers, a large proportion of the rising generation is obtaining technical qualifications by attending technical college part time, usually one day and two evenings per week. These courses usually lead to Ordinary and Higher National Certificates, with optional endorsements. The student, however, does not receive sufficient encouragement to go further than this ; in fact, he is actually discouraged by the qualifications necessary for membership of the senior engineering institutions, hence a large number of potential engineers are lost to the industry. This will be further aggravated by the fact that the senior engineering institutions will probably have to raise their entrance qualifications to keep the membership numbers within manageable limits.

It would appear, then, that a new engineering institution is required, to absorb this large increase in the number of engineers being trained. This new institution could, if necessary, be a stepping-stone from the H.N.C. to membership of one of the senior professional institutions.

I would suggest that this new institution be called " The Institution of Technical Engineers " and that qualifications necessary for associate membership be :

(1) G.C.E. in five subjects at ordinary level, two compulsory subjects being Latin and English language.

(2) Ordinary and Higher National Certificate in Mechanical or Electrical Engineering with two endorsements.

(3) Ordinary National Certificate in one of the following (not included in above) : Mechanical, Electrical or Production Engineering or Physics or Chemistry ; corporate membership of the institution being obtained only by external examinations with no exemptions.

GRAHAM BALL

Bilborough, Notts,
January 5th.

RESILIENCE OF A GYMNASIUM FLOOR

SIR,—As I read Wing-Commander Cave-Brown-Cave's letter in your issue of December 23rd, I had the feeling " This is where we came in." I have already declined in a previous letter to follow Wing-Commander Cave-Brown-Cave into a discussion of the economics of gymnasium equipment, as I have neither the interest nor the qualifications to embark on such a discussion. My only object has been to correct his original claim that sprung floors are, in reality, no better than solid floors, and that any preference for the former is purely psychological. Education authorities, I thought, might be tempted to accept his conclusions as authoritative, with the possible result that a good many children might be deprived of the pleasant experience of doing " gym " on a sprung floor.

I do not suppose that they would come to any great harm if they had to use an " austerity " floor. Neither would dancers who roll back the carpet for an impromptu dance on the unsprung dining-room floor, or the badminton players who elect to play on a concrete floor rather than not play at all. A sprung floor is a luxury and, like all other luxuries, is only justified when it can be afforded without sacrificing essential requirements.

D. WILLIAMS

Farnborough,
Hants,
January 10th.

OSCILLATIONS OF STEEL CHIMNEYS

SIR,—I was very interested in R. E. D. Bishop's article on " Wind-Excited Oscillations of Self-Supporting Steel Chimneys " in your issue of December 30th. I was at the new oil refinery at Shellhaven in 1950, when some 200ft chimneys were erected ; one in particular performed the most violent oscillations which could readily be seen from half a mile or more away, the movement being several feet. Viewed from the base of the chimney the effect was most alarming and it was hard to believe that the welding would stand up for long. As far as I remember the frequency was about 25 to 30 per minute and the occurrence seemed to be unrelated to the wind speed, often being at its worst when there seemed to be hardly any wind at all. At other times, despite wind, the chimney was quite stationary, so other possible causes were investigated.

The chimney was parallel and about 12ft in diameter, with a tapered section near the base making it probably 20ft in diameter where it was bolted down to the foundations. On this site, which is reclaimed land on the north bank of the Thames Estuary, the foundations had to consist of twenty or more reinforced concrete piles 55ft long and 16in square, some being raker piles, all the tops being concreted together to form a massive cap to which the chimney was bolted. In driving the piles it was only necessary to give a few light blows with the hammer to break through the crust, then the piles ran in for 20ft or more with just their own weight plus the hammer resting on top. Ballast was reached about 40ft down and the piles were driven about 5ft into this, till the requisite bearing was obtained.

A long period was spent in investigating the vibrations and it was eventually established that the times at which the chimney vibrated were related to the tides and not to the winds at all. I never believed this myself at the time, but possibly other readers who were there at the same time might have something to say. I was with John Mowlem and Co., who did the foundations, but another firm supplied and erected the chimney. These events took place very soon after the chimney was erected and after many weeks the chimney seemed to settle down and it was possible to carry out the lining and painting. It certainly seemed to me that there were probably a lot of stresses remaining in this chimney which gradually disappeared due to strains resulting from the continued oscillations. The chimney in this case was all-welded, being brought to the site in sections about 25ft long which were welded together on the site and the whole 200ft chimney erected in one piece. The chimney was not to have any guys, and was one of three. I left the site shortly afterwards, but I imagine there was no further trouble and I know the chimneys still exist, as I live in the neighbourhood !

R. C. K. MONEY,
Major, R.E.

York,
January 11th.

INDICATOR PASSAGES

SIR,—I wish to thank Mr. R. K. Vinycomb (THE ENGINEER, December 30, 1955) for pointing out that Fig. 6 in my article (THE ENGINEER, December 16, 1955) is in error. However, the error is not as he has surmised, but is a misplacement of the origin of the horizontal scale : the rates of change of pressure at the reference pick-up should be twenty units less than are shown in Fig. 6 as printed. The derived values shown plotted in Fig. 8 are, fortunately, hardly affected and the mean line not at all. Since Fig. 8 is the figure which would be used in practice, I feel it is unlikely that readers have been misled ; but I give my apologies for any confusion that may have been caused.

J. G. WITHERS

Sunbury-on-Thames,
January 4th.

Literature

Steel Designers' Manual. By CHARLES S. GRAY, LEWIS E. KENT, W. A. MITCHELL, and G. BERNARD GODFREY. London : Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, S.W.7. Price 50s.

THIS book of 909 pages has been prepared for the British Steel Producers' Conference and the British Iron and Steel Federation by a panel of engineers, after consultation with industry, to give practising engineers a manual of present-day knowledge of design of steel-framed buildings. A large number of examples illustrate the various problems in design, the solutions generally being based on the 1948 edition of B.S. 449. The book is not intended as a textbook, although it could certainly serve as one for many purposes. In fact, perhaps one of its faults is that too much space has been devoted to elementary theories of bending, deflections, inertias, &c., and not quite enough to more advanced problems of design, or to the more complex data for it, such as moments in continuous beams of unequal spans and variable inertias, connections of battens, &c.

The first seven chapters deal with beams, giving moments, shears, deflections and influence lines for a large variety of simple, fixed and continuous girders. The next four chapters give elementary analyses of framed structures and influence lines for them. Then follows a very valuable chapter on modern methods of structural analysis in which moment distribution, column analogy, slope deflection and graphical integration methods are explained and illustrated by examples in a precise and clear

manner. Another most useful chapter gives formulæ for reactions and moments for rectangular and pitched roofed portal frames with variable inertias, including sixty pages of data extracted from the monumental work by A. Kleinlogel, and supplemented by sixty-seven specially prepared charts of moments and reactions for the more common types of frames with different ratios of height to span.

A chapter on framing of single-storey sheds, including stressed skin construction, with comprehensive tables of data for design of roof girders and trusses should also be very helpful. There are three interesting contributions by great authors—C. C. Pounder, W. Fisher Cassie and F. A. Partridge—dealing with flat plates, beams in torsion and plastic theory of design respectively. Chapters on design of stanchions, struts, tension members, and plate girders are perhaps a little on the elementary side and somewhat biased towards riveted construction, but a chapter on the welded joints in rigid framed structures is of exceptional interest and contains the latest information on the subject. Type designs of complete engineering workshop and of a coal bunker are fully worked out and clearly illustrate the application of B.S. 449 to practical design. A large number of tables giving strengths of rivet and weld groups will also be very helpful, but some of the other tables, particularly those at the end of the book, could be omitted without loss as they are given in most section books, which are always at the designer's elbow and which the new manual is not intended to replace.

The first edition of such a large and comprehensive work must contain some errors, and several such could be mentioned, also the index could be more comprehensive, but on the whole, the book is remarkably well produced, illustrated and edited. It is perhaps a little unfortunate that its text is irrevocably linked up with the current B.S. 449 and L.C.C. by-laws, as, in consequence, some parts are in danger of becoming obsolete in the near future. However, there is no doubt that, to-day, this book will be a most valuable addition (at comparatively small cost) to the library of every steelwork designer and that its value will continue to grow if it is used as a constant companion in design, rather than as yet another reference book shelved for an emergency.

Theory of Machines. By W. G. GREEN. Glasgow: Blackie and Son, Ltd., 17, Stanhope Street, C.4. Price 40s.

ONE'S first reaction to Professor Green's book is occasioned by its size, for it contains over 1000 pages. Used as a textbook in parallel with a lecture course, it will provide a valuable aid and means of consolidation, though the private and probably inexperienced student may not find it easy to pinpoint the essentials for the purpose of his examination. The book is, in fact, a treatise on the well-established branches of machine theory with which it deals and will profitably serve a very wide range of readers for purposes of reference.

The author has kept in mind that the theory of machines describes the art of applying the principles of mechanics in order to provide basic data for the design of machines which are satisfactory as regards functional and endurance requirements. These principles are presented in the first two chapters, which cover kinematics and two-dimensional dynamics for both finite and impulsive forces. The treatment is formal with perhaps bias towards the methods of the applied mathematician rather than the engineer. This work is an earnest of the author's aim that the student shall be suitably prepared and equipped to deal with the applications to machine problems which follow.

The characteristics of mechanisms and their elements receive full and generous consideration. A few of the geometrical topics are of specialised rather than basic educational interest, but the important groundwork is well covered. The reader is very usefully introduced to conceptions of degrees of freedom, constraint and kinematic design. In the determination of velocities, extensive use is made of the instantaneous centre and the corresponding emphasis on the acceleration centre is commendable. The acceleration diagram technique for the rotating-bar-and-slider type of mechanism would have been enhanced by the introduction of the point on the bar coincident with the slider which not only helps to demonstrate how the four component accelerations arise, but also introduces an additional image on the diagram. The principle of rate of working is applied in determining the forces transmitted by a mechanism and inertia forces are effectively treated by graphical methods.

The reciprocating engine mechanism is given comprehensive attention which covers the kinematics, turning moment and energy fluctuation. The chapter on engine governors is perhaps noteworthy for its inclusion and treatment of the inertia governor, a subject often neglected by previous authors. Engine balancing methods follow conventional lines, though a graphical method which is not well known is introduced for the primary balance of four-cylinder engines. The detailed and somewhat involved analysis of the radial engine will no doubt encourage the use of the alternative method given which employs direct and reverse cranks. This will perhaps be a good thing, at least for the student.

Solid friction is very adequately treated as regards principle, friction appliances and coil friction. In an interesting chapter devoted to film lubrication, the subject is developed from fundamentals. The viscous flow conditions in a thin film are carefully explained though the inclusion of fluid velocity diagrams at various points in a typical film would have helped the reader even further to understand the effects of the pressure gradients and the frictional tractions. The two-dimensional hydrodynamic theory is developed and applied to problems which include the complete journal bearing and the pivoted plane pad. This is a valuable introduction of the undergraduate student to the work of Reynolds, Sommerfeld and Michell. In the author's analytical method for cams, a general equation for the follower velocity is expressed basically in terms of the equations to the cam profile referred to axes fixed to the cam. For a particular cam, the problem of obtaining the follower velocity and acceleration is then reduced to that of deriving the cam profile equations and applying them to the general equation. An excellent chapter is provided on vibrations and whirling and perhaps the present-day value of the book might have been increased by the extension of this work, possibly at the expense of the section on steam engine valve gears and diagrams.

The step from two to three-dimensional dynamics is not a small one and in no branch is this more forcibly demonstrated than in the treatment of gyroscopic torque. The author comes to grips with this subject by the use of rotating axes and the analysis is kept within reasonable bounds as far as possible by fixing the origin or placing it at the centre of gravity and taking axes along the principal inertia directions. Reduced forms of Euler's dynamical equations are derived and applied to problems, two of which are of a somewhat advanced nature, though easier applications are not neglected.

The book is very readable and contains many examples of an excellent type. For its range and content it is reasonable in price, particularly on present-day standards.

Power System Plant. Edited by E. OPENSHAW TAYLOR, B.Sc., A.C.G.I., M.I.E.E. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 30s.

A SERIES of advanced courses on subjects of interest to power system engineers was organised recently by the electrical engineering department of the Heriot-Watt College, Edinburgh. Some of these lectures were subsequently published in book form. The first volume appeared in 1954 under the title *Power System Transients.* The second book, now under review, was based on a later course of lectures on power system plant. The text is essentially a symposium of lectures rather than a complete treatise and the reader will be able to judge the scope and usefulness of the book by a perusal of the subject titles and lecturers: non-salient pole synchronous machines, by W. J. Carfrae; salient pole synchronous machines by M. G. Say; load frequency and excitation control of synchronous machines, by N. V. Pestereff; transformers, reactors and voltage regulators by R. W. Flux; switchgear principles, by E. O. Taylor; switchgear practice and substation plant, by A. Erskine and M. D. Kippen; underground cables, by L. G. Brazier; overhead lines, by A. Erskine. Some gaps in the subject matter are, of course, inevitable: for example, the subject of protection is not dealt with at all; and the treatment of some topics—instrument transformers, insulators and busbars—is necessarily brief. Nevertheless, to have covered so wide a theme as power station plant in what is essentially a compendium of lectures by independent authorities, and to have produced the result in a book of 300 pages is a worthwhile achievement.

The Book of the Lathe. By C. T. BOWER, A.M.I.Prod.E. London: Odhams Press, Ltd., 96, Long Acre, W.C.2. Price 15s.

THIS is essentially a practical book designed to cover all aspects of the lathe from its selection, adjustment and care to its tooling and uses for various classes of work. The versatility of the lathe is such that all its users, from the oldest amateur to the skilled machinist, can always learn some new method of doing a job or of a fitting to widen its scope of application or improve its accuracy or rate of production. For this reason the way in which the author has introduced into the basic descriptive matter on lathes a considerable number of useful hints and ideas, based on his own practical experience, adds much to the value and interest of the book. Possibly much of the general information given will be familiar to the skilled turner, but for the amateur, and particularly the trainee machinist, the book provides knowledge which will always stand him in good stead. The clear way in which the descriptive matter is presented, without the irritating reference to obvious detail so common in many practical books, will appeal to the practical reader. A large number of diagrams, drawings and photographs are used to supplement and clarify the notes wherever necessary. The book is certainly a useful addition to the literature on lathes.

Engines at the National Boat Show

Petrol and diesel engines representative of those suitable for the powering of small craft, ranging from a dinghy to a large yacht, were exhibited at the National Boat Show by most of the manufacturers of engines of moderate power. Some of the engines are of established design and performance, several are new, while others are improved versions of successful models.

THE second National Boat Show which was held at Olympia from December 29, 1955, to January 10, 1956, contained many examples of the boat builders' art in the form of dinghies, rowing boats, motor boats, runabouts, motor cruisers and yachts constructed of wood, plywood, aluminium alloy and glass fibre. Also on view was an extensive selection of auxiliary gear, boats' fittings, navigational equipment and boat-builders' tools.

John I. Thornycroft and Co., Ltd., showed several engines, including the diesel "Handybilly," which has been designed as the successor to the petrol/paraffin engine of the same name. The new engine, which we illustrate in Fig. 1, is a four-stroke, direct-injection unit having two cylinders of 3⅜in bore by 4½in stroke, a compression ratio of 16·6 to 1, and has a heavy duty rating of 12½ s.h.p. at 1500 r.p.m. and a maximum output of 16 s.h.p. at 1800 r.p.m. It drives through a 2 to 1 reduction gear integral with the engine, which starts from cold and incorporates a

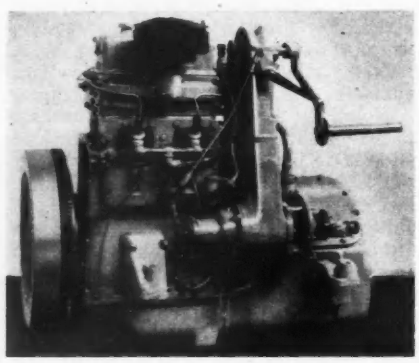


Fig. 1—Thornycroft R.J.D.2 four-stroke two-cylinder diesel "Handybilly" engine. Maximum output 16 s.h.p. at 1800 r.p.m.

device which automatically returns the decompressor to the full compression position after a given number of turns of the starting handle. This engine, the Mark R.J.D.2, can be used as a direct replacement of the Mark D.B.2, since the mounting arrangements are identical.

A chromium iron casting forms the crankcase and incorporates the cylinder block while the same material is used for the cylinders which are of monobloc design and fitted with dry liners. The combustion chamber is formed in the crown of the aluminium alloy pistons, each fitted with one chromium-plated and two plain compression rings and two oil control rings. Lead-bronze bearings are fitted to the big ends and bronze bushes to the small ends of the connecting-rods, which are steel stampings, while three copper lead-lined bearings carry the alloy cast iron crankshaft. A camshaft of chilled cast iron carried in a tunnel in the crankcase operates the air and exhaust valves through short push rods and is driven by gears from the crankshaft. An air silencer is carried on the cast aluminium air inlet manifold.

Light distillate gas oil is used and injection is by C.A.V. pumps through multi-hole injectors, the consumption at maximum power being about ¾ gallon per hour. The fuel supply is controlled manually in conjunction with a governor which runs at one-and-a-half times engine speed. Lubricating oil is delivered under pressure to the main and connecting-rod bearings and to the valve gear by a plunger pump; cooling is by fresh water circulated in a closed system by a centrifugal pump, in association with an external heat exchanger. The engine, which has a dry weight of 780 lb, has been approved for use in lifeboats.

Another item was the oil-operated type "B" reverse gear, Fig. 3, which has a maximum capacity of 800 lb per foot input torque at 2200 input shaft revolutions per minute and can be arranged to incorporate reduction ratios from 1·0 to 1 to 4·0 to 1. The ahead and astern clutch assemblies consist of metal-to-metal cone clutches which are self-adjusting for wear and the input, main and output shafts are heat-treated high-grade alloy steel forgings. Two oil pumps are fitted, one driven by the input shaft and the other by the output shaft, and there is an adjustable oil pressure relief valve. Casings can be made in cast iron or aluminium alloy and the dry weight of the gear, with a light metal casing, is 770 lb.

On the stand of Ajax Marine Engines, Ltd., were the "Albacore," of 30/40 b.h.p. at 1400/1600 r.p.m., the "Amazon," of 65/90 b.h.p. at 1800/2200 r.p.m., and the "Apollo," of 95/125 b.h.p. at 1600/1800 r.p.m., representative of engines having a power range of 30 b.h.p. to 150 b.h.p. All the units are of direct-injection, four-stroke design. The "Apollo," seen in Fig. 2, is a six-cylinder overhead valve, water-cooled engine, built by Leyland Motors, Ltd., having a bore and stroke of 4·8in by 5·5in and a compression ratio of 15·75 to 1. A monobloc casting forms the cylinder block and crankcase and is fitted with prefinished dry cast-iron liners, while the detachable cast iron cylinder heads cover three bores each and incorporate stellite-faced renewable valve seats.

Three compression and two scraper rings are fitted to the aluminium alloy pistons, which have the combustion chamber machined in the crown, and the connectings-rods have phosphor-bronze bushes at the small ends and prefinished copper-lead, steel shell, indium coated big end bearings. Seven similar bearings carry the forged alloy steel crankshaft, which has nitrided bearing surfaces. Hardened and ground helical gears drive the forged steel camshaft from the crankshaft. Fuel injection equipment consists of a diaphragm lift pump, mounted on a C.A.V. injection pump, and four-hole injectors and the lubricating oil is circulated by a gear pattern pump at the rate of 5 gallons per minute. The

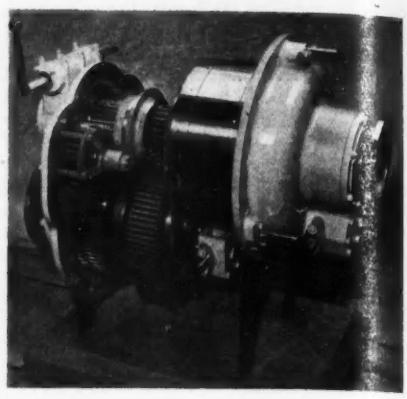


Fig. 3—Thornycroft "B" type oil-operated reverse gear

sump has a capacity of 7 gallons and the oil is cooled in an oil-water heat exchanger. Electric starting is provided and there is a cradle mounted 5in, 24V dynamo driven from the timing gears.

Among the power units displayed by The Parsons Engineering Company, Ltd., were the range of engines which are marine versions of the Armstrong-Siddeley air-cooled industrial diesel engines. They are single, twin and three cylinder units known as the "Goosander," "Merganser" and "Peregrine," respectively. The "Peregrine" is the latest addition to the range and is a three-cylinder, four-stroke, direct-injection, cold-starting, air-cooled, compression-ignition engine developing 33 b.h.p. at 1800 r.p.m. at an approximate fuel consumption of 1·66 gallons per hour. The unit is a square engine, having a bore and stroke of 108mm and a capacity of 2964 litres. A fan incorporated in the flywheel delivers cooling air through ducts to fins on the cylinders and cylinder heads and the injector nozzle holders are also located in the air stream. There are separate fuel injection pumps, operated from the camshaft by a rocker arm and fuel is supplied through a filter by a diaphragm lift pump. A rotary pump circulates the lubricating oil and starting is by a handle operating on the half-speed shaft.

A new type "A" reverse/reduction gear was also on view. It has been designed for use with engines transmitting ¾ b.h.p. per 100 r.p.m. up to 1800 r.p.m. The gear is operated by an external lever and is contained in an oiltight casing, and the input shaft is supported in dual-performance ball bearings, while the output shaft is carried in a phosphor-bronze bearing. The input shaft carries the ahead cone and the drive

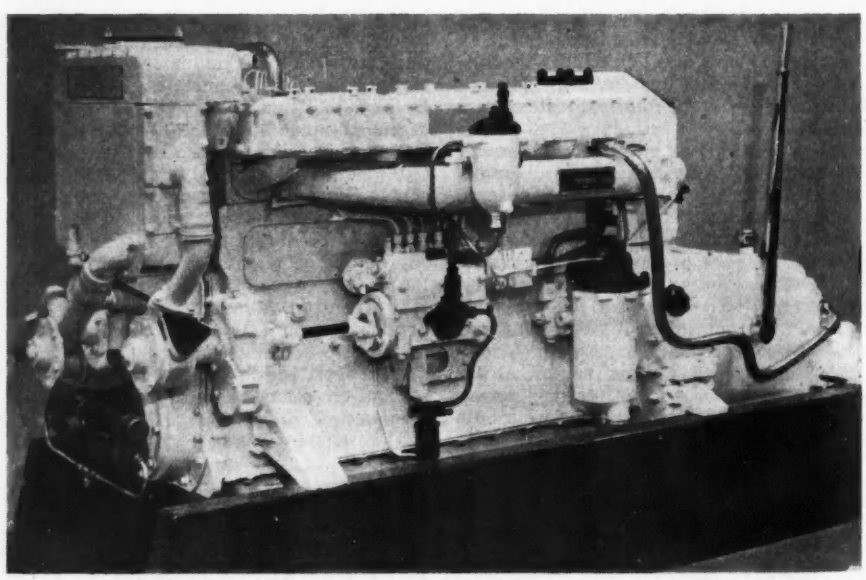


Fig. 2—Ajax "Apollo" four-stroke, six-cylinder, diesel engine developing 125 b.h.p. at 1800 r.p.m.

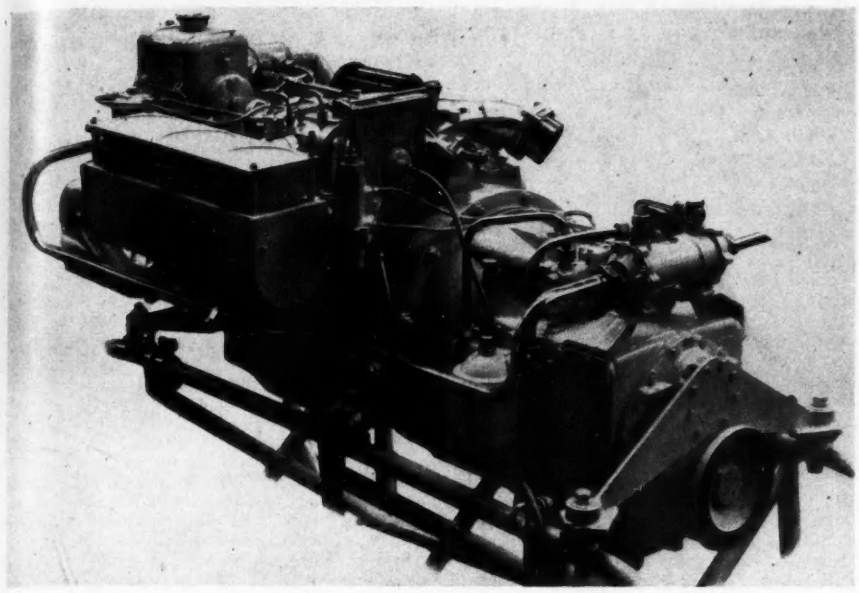


Fig. 4—Rootes-Lister T.S.M.3 opposed-piston diesel engine rated at 77 b.h.p. at 1800 r.p.m.

to the lay shaft over it, and the output shaft carries the aft cone, which has a ball bearing thrust race between it and the bearing flange. Between the forward and aft cones is the male driving cone, mounted and keyed to the aft shaft, and at either end are plates, which abut on to shoulders on the aft shaft, and between which are springs to allow for load application and automatic adjustment. A chain and sprockets give reversal of rotation to a pair of driving gears between the lay shaft and the astern driven cone and a cam keyed to the operating lever shaft forms the operating mechanism. This cam moves a fork lever which carries a pivoted yoke and transforms cam movement into axial travel of the aft shaft to engage the driven cone with either the ahead or astern cones.

R. A. Lister (Marine Sales), Ltd., showed a full range of the "Freedom" engines, which are rated at 9 h.p. per cylinder at 1800 r.p.m., also examples of the company's L.D.M. air-cooled diesel engines, rated at 3½ h.p. per cylinder at 1800 r.p.m., and generator sets. Another engine on the stand was the Rootes-Lister T.S.M.3 three-cylinder, direct-injection, water-cooled, horizontally-opposed piston, two-stroke diesel unit, which has a bore of 3·25in by a stroke of 4in by 2in. The engine, which has blower-assisted scavenging and a capacity of 199 cubic inches, is rated at 77 b.h.p. at 1800 r.p.m. and is shown in Fig. 4. A single iron casting forms the crankcase and cylinder block, which is fitted with wet cylinder barrels. Each cast iron piston is connected to the alloy steel drop-forged crankshaft, which is carried in four thin wall steel-backed babbitt-lined bearings by a piston-rod, a rocker arm and a connecting-rod. The rods are H-section alloy steel forgings and the connecting-rod has big end bearings of shell pattern, having the top half lined with copper-lead-indium and the bottom with babbitt metal. A C.A.V. injection pump, which embodies a mechanical lift pump, supplies fuel to single-hole injectors, of which there is one per cylinder, and a large gear pattern pump provides lubricating oil at high pressure to the bearings. The normal sump capacity is 28 pints. Closed fresh water cooling is provided, a centrifugal pump circulates the water and the cooling water, lubricating oil for both engine and gearbox are cooled by sea-water circulated heat exchangers.

Nine engines representative of the petrol and diesel units manufactured by the company were exhibited by the Coventry Victor Motor Company, Ltd. They included the Mark W.N.4 horizontally-opposed, twin-cylinder petrol unit of 14/16 b.h.p., the W.D.2 of 7/9 b.h.p. representing the vertical cylinder marine diesels, the four-cylinder horizontally-opposed "Neptune" petrol engine of 18/26 b.h.p., the 14/22 b.h.p. "Victor Vixen" diesel unit, and the M.W.2 "Midget" four-stroke, horizontally-opposed, twin-cylinder petrol engine, which develops 3½ b.h.p. at 1500 and 6 b.h.p. at 2500 r.p.m. This engine, which has a bore and stroke of 60mm, was shown as a compact lightweight unit with sailing clutch direct coupled to stern gear and in this form has a weight of 79 lb.

F. Perkins, Ltd., showed three models of the four-cylinder, four-stroke diesel engine L4(m), which has a bore of 4¼in and a stroke of 4¼in and develops 58 b.h.p. at 2000 r.p.m. A different stern gear was exhibited with each engine and included Slack and Parr variable-pitch propeller and stern gear, Parsons type "F" 2 to 1 reduction and reverse gearbox, and a Mark MRF 11/2B 2 to 1 oil-operated reduction gear. The six-cylinder S.6.(m) engine of 75 b.h.p. at 1500 r.p.m. and 100 b.h.p. at 2000 r.p.m. was mounted with a M.R.F. 10A oil-operated 3·68 to 1 reduction and reverse gear, while the P.6(m) was shown with a M.R.11/1B. oil-operated reverse gear and direct drive, as shown in Fig. 5. This six-cylinder, four-stroke engine of 3½in bore by 5in stroke has an output of 43 and 65 b.h.p. at 1250 and 2000 r.p.m. respectively and an installation angle of 12 deg.

The largest engine in the show was the Mercédès-Benz Mark M.B. 518A twenty-cylinder vee unit on the stand of Arthur Bray, Ltd. The cylinders are arranged in two banks of ten and the engine, which has a bore of 185mm, a stroke of 205mm and a compression ratio of 14 to 1, develops 3000 b.h.p. at 1720 r.p.m. on a weight of 3·4 lb per brake horsepower, the dry weight being 4700 kg. The final drive is through a 1·72 to 1 reduction gear and an air-operated reverse gear integral with the engine. The engine, which has a length overall of 4000mm, a total height of 1685mm and width between base supports of 635mm, has a compression pressure of 40 kg/cm² and is fresh water cooled, there being one pump for each bank of cylinders. Fuel is delivered by four Bosch pumps, each supplying five cylinders, arranged two at each end of the engine, and the controls allow for two pumps to be cut out so that the engine runs on one cylinder bank. Air starting is arranged on two cylinders. Lubricating oil is circulated by two two-stage pumps, which operate in both directions, and the Brown-Boveri blower has an oil-operated disc clutch, which automatically disconnects the blower when the engine is reversed. The boost pressure varies from 0·43 to 0·50 kg/cm², according to revolutions per minute, and the system includes a sea-water cooled intercooler. Other engines on the stand included the 40–45 h.p. M.D.6 David Brown marine diesel four-stroke unit, having a bore and stroke of 3⅛in by 4in, a full-load speed range of 800 to 1800 r.p.m., and a compression ratio of 15·9 to 1.

A launch on the stand of the Rowhedge Ironworks Company, Ltd., was distinguished from other craft in that it was fitted with a "Gill" hydraulic jet propulsion unit which dispenses with the usual stern gear and also the need for a rudder. This form of propelling unit allows for navigation in shallow water and also permits full power to be applied in any direction without altering the speed of the engine or declutching. The craft has a length overall of 24ft by 8ft beam by 3ft depth and a draught of 11in, and the "Gill" hydraulic jet unit driven through a 2 to 1 reduction gear by a Morris "Navigator" engine gives the boat a speed of 8 m.p.h. The propulsion unit consists of a "Gill" pump mounted within a short syphon-shaped passage, which has both ends open to the sea. Water is drawn in at one end of the passage and discharged at the other end through a rotatable discharge deflector consisting of a number of vanes having the form of steam turbine blades. These vanes deliver the water in a horizontal stream which can be directed to any point of the compass, the thrust depending upon the revolutions per minute at which the unit is driven.

Another engine exhibited was the Standard marine diesel "Seamaster," produced by Sea Enterprises (London), Ltd. This unit has four cylinders of 3 3/16in bore by 4in stroke, a compression ratio of 17 to 1 and at a maximum governed speed develops 29 b.h.p., the maximum torque being 1010 lb per inch at 1100 r.p.m. The cast iron cylinder block has centrifugally cast slip fit liners and the cast iron cylinder head incorporates a spherical combustion chamber. Aluminium alloy pistons are fitted and both the connecting-rods and crankshaft are of manganese molybdenum steel and have lead-indium steel-backed bearings. A chain-driven camshaft operates overhead valves through push rods and the fuel system consists of a mechanical lift pump and C.A.V. injector pump, nozzle holders and nozzles. The sump has a capacity of 12 pints and a high-capacity pump

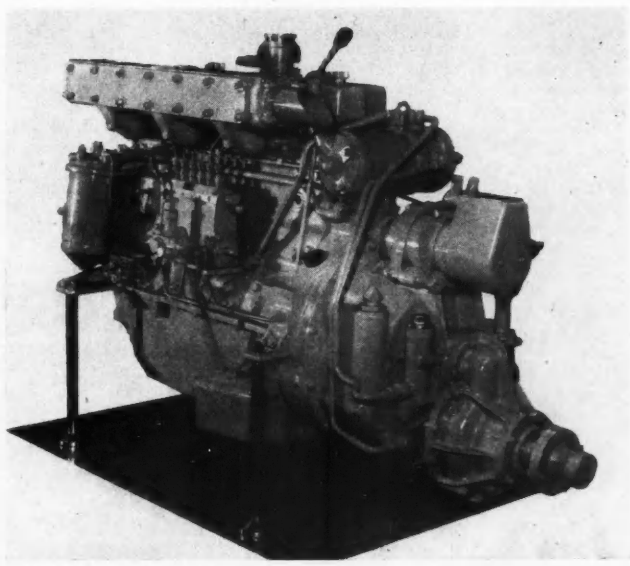


Fig. 5—Perkins P6(M) engine, with MR 11/1B oil-operated reverse gear and direct drive

feeds lubricating oil under pressure to all bearings, while a centrifugal pump circulates the cooling water. The engine, which drives through a Parsons " F " reverse gear, weighs 747 lb.

A wide range of engines was displayed by the Bolinders Company, Ltd., and included two, three and four-cylinder models of the " 105 " series which develop 23 b.h.p., 35 b.h.p. and 46 b.h.p., respectively, at 1500 r.p.m. Also shown were several " Penta " engines, namely, the M.D.96, which is a six-cylinder direct-injection, four-stroke unit, having a compression ratio of 17 to 1, a bore and stroke of 120·65mm by 140mm and developing 35 b.h.p. at 2200 r.p.m. A supercharged version of this engine, known as the KMD.96, was also on the stand, and fitted with a belt-driven Roots blower, it develops 150 b.h.p. at 1800 r.p.m. The lightweight, four-cylinder, four-stroke, B.B.50 petrol engine which weighs 408 lb, has twin down-draught carburettors and has an output of 50 b.h.p. at 3500 r.p.m., was shown with a 1½ to 1 reduction vee drive unit.

On the stand of The Brush Group, Ltd., were several single and twin cylinder cold-starting, air-cooled diesel marine propulsion units representative of the engines manufactured by Petters, Ltd., and also a range of water-cooled, cold-starting marine diesels built by J. and H. McLaren, Ltd. There were two, three and four-cylinder models of the Petter-McLaren BM Series II diesel engines which develop 20 b.h.p., 30 b.h.p. and 40 b.h.p., respectively, at 1500 r.p.m. These totally enclosed compression-ignition, four-stroke engines have a bore and stroke of 110mm and a compression ratio of 16 to 1. The crankcase and cylinder head are of cast iron and removable wet cylinder liners of centrifugally spun cast iron are fitted. Copper-lead-lined thin-shell steel-backed bearings are fitted to the forged connecting-rods, while the crankshaft is carried in similar bearings but white metal-lined. A pneumatic governor controls the engine speed and the fuel system is arranged for gravity feed with individual fuel injection pumps operated by rocker gear from a camshaft. Fuel is injected directly into a hemispherical bowl in the crown of an aluminium alloy piston which has three compression rings, the top one being chromium-plated, and two oil scraper rings. A gear pump delivers oil under pressure to all main bearings and a plunger pump circulates the cooling water through the engine and discharges overboard.

Henry Meadows, Ltd., exhibited examples of the engines manufactured by the Bergius Company, Ltd., as well as a comprehensive group of its own marine products, with outputs ranging from 15 s.h.p. to 214 s.h.p. One interesting application was the use of the company's Mark 4D.J.330 four-cylinder, four-stroke industrial engine, as the power unit for a model 60 HMR " Harbourmaster " propulsion unit. The engine has a bore and stroke of 120mm, develops a maximum of 85 b.h.p. at 2200 r.p.m., and has a closed circuit fresh water system with a centrifugal pump and a thermostatically controlled radiator.

Technical Reports

The Effect of Tight Clamping on the Fatigue Strength of Joints. By W. A. P. Fisher and W. J. Winkworth. R. and M. No. 2873. H.M.S.O. Price 3s.—Tests on " Z "-section stringers of aluminium connected to long slotted cleats have shown endurances for tightly clamped joints about nine times that for unclamped joints. Tests of bolted joints in sheets of similar material show still greater improvement for very tight clamping.

Electrode Processes in Spark Discharges (Ref. L/T287). By R. Craig. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 12s. 6d., postage 3d.—The effect of different electrode materials on the voltage/gap-length characteristics of 6-sec, 100A, rectangular-current-pulse spark discharges in H_2, air and A has been investigated. Values of the total electrode voltage drop have been deduced and are between 13V and 29V for most metal electrodes. The electrode volt drop is, therefore, of the same order as in the continuous arc. It was also found that the electrode voltage drop of the spark discharge is independent of gas pressure (5cm to 80cm Hg) and of current (50A to 1000A).

Use of Sodium and of Sodium-Potassium Alloy as a Heat-Transfer Medium

By W. B. HALL, B.Sc. (Eng.),† and T. I. M. CROFTS‡

No. I

At the Institution of Mechanical Engineers, on January 13th, a description of some experimental work on liquid metal circulating systems was presented. The greater part of the paper is reproduced here.

THE advent of the nuclear reactor as a heat source, with its almost unlimited potential heat rating, has stimulated the search for a heat-transfer medium capable of operating over a wide temperature range with a good heat-transfer coefficient. As a consequence, the use of liquid metals for this purpose has received much attention during the past few years. In the design of a reactor cooling circuit, many limitations are imposed by nuclear physics, and it is not necessarily the case that a good reactor coolant is also the best choice for an industrial heat-transfer process. It appears, however, that sodium and sodium-potassium alloy are suitable for general application to heat-transfer problems when high heat fluxes and temperatures are concerned.

For industrial application the wide temperature range over which many liquid metals can be used is likely to be at least as attractive as the high heat-transfer coefficients which are obtained. In contrast with the nuclear reactor, it may be neither necessary nor desirable to operate at heat fluxes which are as much as ten times those in a modern water-tube boiler ; much of the apparent advantage of so doing is lost in excessive temperature drops through walls of pipes. For example, it is possible to achieve a heat flux of 1kW per square centimetre (about 3×10^6 B.Th.U. per square foot per hour) with sodium at a temperature difference between the surface and the liquid metal of about 100 deg. Cent.; at this heat flux the temperature gradient in a stainless steel wall would be about 500 deg. Cent. per millimetre (or 250 deg. Cent. across a 0·020in wall). Clearly, if the temperature drop across the wall is not to dominate the heat-transfer process the wall must be exceedingly thin ; conversely, if the wall cannot be thin, such high heat fluxes will produce excessive thermal stresses in it.

At the outset of the work described in this paper the choice of liquid metal seemed to be between mercury, sodium and sodium-potassium alloy, and the various lead-bismuth or lead-bismuth-tin alloys. It was clear from the literature on the subject that sodium or sodium-potassium had an advantage over mercury and lead-bismuth as far as corrosion of steel was concerned ; it is also cheaper, and it has a much more useful working temperature range than mercury. Mercury has the further disadvantage that its vapour is highly toxic. The main disadvantages of the alkali metal lie in the prevention of oxidation either inside the apparatus where the oxide may block the pipes, or outside where it may cause a fire ; there is also the reaction with water, which may in certain circumstances cause an explosion. In spite of these disadvantages it was decided that the work should be concentrated upon sodium and sodium-potassium alloy.

An important factor enabling this decision to be reached was the pioneer work carried out by a group at the Atomic Energy Research Establishment at Harwell under the leadership of Dr. S. Bauer ; some of this work has been reported in the *Proceedings* of the Liquid Metal Utilisation Conference, 1954.

The initial experimental programme was directed mainly along two lines : first, measurements of heat-transfer coefficients under conditions of cleanliness which could reasonably be attained in an industrial plant; secondly, the investigation of handling problems, such as pumping, flow measurement, level control, and the cleaning of plant before and after its use with the liquid metal. The work was later extended to cover cavitation, the testing of heat exchangers for use with sodium on one side and water on the other, the calibration of electromagnetic flow meters, and the investigation of methods of measuring and controlling the amount of oxide present in the apparatus. An important by-product of the work is the experience gained both in the design and the operation of liquid metal circuits. Throughout the work emphasis has been placed on the use of conventional techniques wherever possible ; this principle has been departed from only where the use of a liquid metal introduces a simpler process, or where experience has shown normal practice to be unsuitable.

Description of Experimental Plant

Eight liquid metal circuits have been built and operated during the three years in which the work has been in progress. Most of these conform to one of the three types which are described below. Detailed discussion of the features common to all the circuits and of the methods employed in their construction is given under the heading " Design and Operational Problems."

Electromagnetic Pump Test Circuit.—A diagram of the equipment is shown in Fig. 1. Its purpose was to measure the performance of an electromagnetic induction pump over a range of temperatures and with sodium-potassium alloys of various compositions. The pump was placed in a rectangular loop in stainless steel pipe of 4in nominal bore ; after leaving the pump the metal passed through a flow meter with a nozzle 3·15in in diameter, a control valve, an electromagnetic flow meter, and thence back to the pump inlet. measurements of the inlet and outlet pressures at the pump and the differential pressure across the nozzle flow meter enabled the characteristic curve of the pump to be determined.

The lowest point of the main circuit was connected to a reservoir tank from which the liquid metal could be displaced into the circuit by nitrogen under pressure. This tank was fitted with three globe valves, which were immersed in the liquid metal and operated by spindles passing through glands in the top of the tank. The first valve was used for filling the tank with sodium-potassium alloy from the steel carboys in which it is supplied. The second valve was used to fill the circuit through a sintered stainless steel filter, and the third to drain the circuit, by-passing the filter. The tank was fitted with a level measuring device, which is described in the section on " Level Measurement."

The control valve, situated at the highest point of the circuit, was also employed as an expansion chamber, and the valve spindle passed through the nitrogen-filled space above the liquid metal surface and then through a gland. At a later stage observation windows were fitted above the metal surface.

Finally, the circuit was fitted with a by-pass cold trap, for the continuous removal of oxide from the liquid metal ; this extremely important device is fully described under the heading " Oxide Removal." Initial tests were terminated by oxide contamination after only a few hundred hours ; since the cold trap was fitted the circuit has run for 10,000 hours without contamination.

Apparatus for Heat-Transfer Measurements.—The apparatus, which is illustrated in Fig. 2, is of the " figure-of-eight " type, in which the heat exchanger under test is used regeneratively, thus reducing the amount of heat which must be supplied for a given total heat exchange. It was decided to use a double-annulus heat exchanger

Notation

c—Specific heat of liquid metal, cal. gramme^{-1} deg. Cent.$^{-1}$
d—Diameter of tube, centimetres.
d_e—Effective diameter of annulus, $d_o - d_i$, centimetres.
d_i—Inner diameter of annulus, centimetres.
d_o—Outer diameter of annulus, centimetres.
h—Differential pressure across Venturi, kilogrammes centimetres^{-2}.
k—Thermal conductivity of liquid metal, cal. centimetres^{-1}, sec.$^{-1}$, deg. Cent.$^{-1}$
P_c—Cavitation pressure, kilogrammes centimetres^{-2}.
P_i—Pressure at pump inlet, kilogrammes centimetres.$^{-2}$
Pr—Prandtl number, $c\mu/k$, dimensionless.
P_t—Pressure at Venturi inlet, kilogrammes centimetres^{-2}.
Nu_a—Nusselt number for an annulus, $\alpha d_e/k$, dimensionless.
Nu_t—Nusselt number for a tube, $\alpha d/k$, dimensionless.
r_i—Inner radius of annulus, centimetres.
r_o—Outer radius of annulus, centimetres.
Re—Reynolds number, $Vd\rho/\mu$, dimensionless.
V—Velocity, centimetre second^{-1}.
α—Heat-transfer coefficient, cal. centimetres^{-2}, second^{-1}, deg. Cent.$^{-1}$
ρ—Density of liquid metal, gramme centimetres^{-3}.
μ—Viscosity of liquid metal, gramme centimetres^{-1}, second^{-1}.

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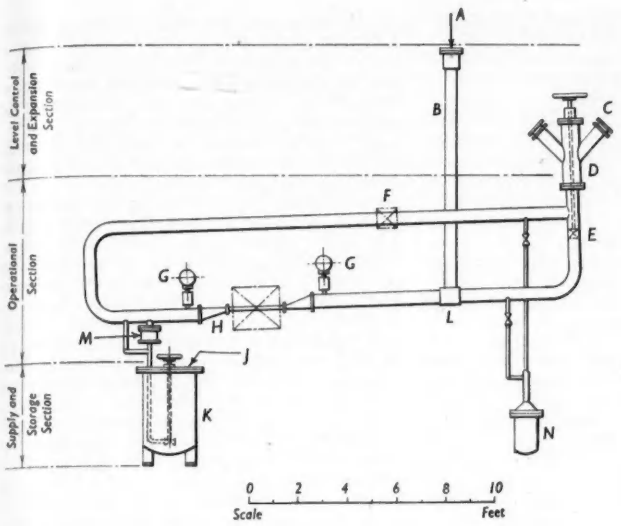
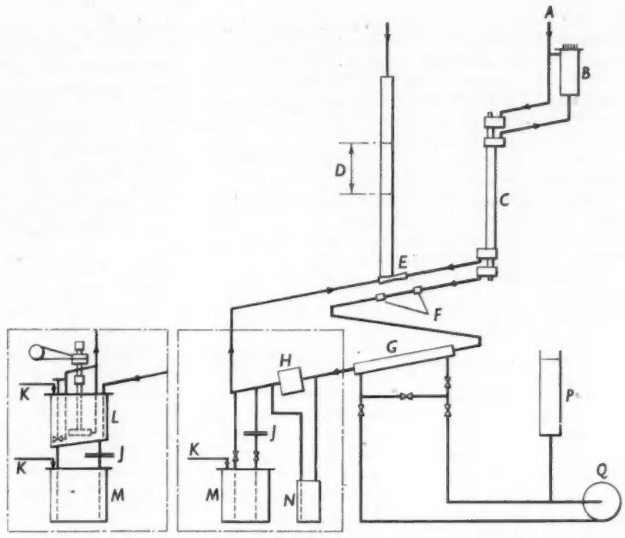


A—Nitrogen supply.
B—Manometer tubes
C—Inspection ports.
D—Expansion and level control chambers.
E—Control valve.
F—Electromagnetic flow meter.
G—Diaphragm pressure gauges with trapped gas vessels.
H—Electromagnetic pump.
J—Nitrogen supply.
K—Reservoir tank.
L—I.S.A. nozzle flow meter.
M—Filter.
N—Cold trap.

Fig. 1—Layout of electromagnetic pump circuit



Showing mechanical pump in early experiments with sodium and electromagnetic pump in experiments with sodium-potassium.

A—Nitrogen supply.
B—Electric heater tank.
C—Heat exchanger (see Fig. 3).
D—Pressure difference across Venturi meters.
E—Venturi meter.
F—Electromagnetic flow meter.
G—Cooler.
H—Electromagnetic pump.
J—Filters.
K—Nitrogen supply.
L—Mechanical pump.
M—Reservoir pump.
N—Cold trap.
P—Coolant reservoir.
Q—Coolant circulating pump.

Fig. 2—Layout of heat-transfer apparatus

(Fig. 3) rather than the more usual tube and annulus design, since it would then be possible to measure axial temperature gradients on the inner as well as the outer tube, and thus to separate the effect of the entrance on the heat-transfer coefficient. The flow of liquid metal was maintained by a centrifugal pump in the earlier experiments, and later by a single phase electromagnetic pump. The centrifugal pump was immersed in the liquid metal and driven by a shaft, carried on bearings outside the tank, which passed through a gas-seal gland in the tank lid. Some trouble was experienced owing to the presence of sodium vapour in the gas space, and maintenance of a good gas seal was difficult ; no doubt this could have been overcome by further development work, but at this time a small single phase electromagnetic pump became available, and was therefore used to replace the centrifugal pump. Flow measurement was by means of a Venturi tube, the pressure difference being measured by means of an inverted U-tube, as will be described in the section "Level Measurement."

A heat input of 20kW could be effected by means of electric heaters at one end of the loop, and a sodium to Downtherm heat exchanger was used to reject this heat at the other end. Measurements of the temperature rise along the length of the heat exchanger were then used, in conjunction with the measured mass flow and the temperature difference between the two streams of liquid metal, to determine the overall heat-transfer coefficient.

The method of filling the apparatus, the level control of the free surfaces, and the oxide removal

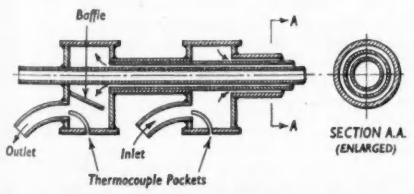


Fig. 3—Detail of double-annulus heat-exchanger end

equipment were basically the same as for the pump circuit described above.

Apparatus for Experiments at High Heat Fluxes.—The main purpose of this experiment was to investigate the effect of high heat fluxes, and consequently high temperature gradients and thermal stresses, on tubes of various materials. A secondary purpose to which the apparatus has been put is the provision of testing facilities for various small liquid-metal-to-liquid-metal and liquid-metal-to-water heat exchangers. The experimental results obtained with this apparatus are not within the scope of the present paper, but the design and operation of the equipment may be of interest.

The apparatus is shown in diagrammatic form in Fig. 4. Firstly, it will be seen that the equipment for storing the liquid metal and supplying it to the apparatus is basically similar to that in the two circuits which have already been described. Nitrogen is used to displace the liquid metal from the reservoir tank into the apparatus by way of a sintered stainless steel filter ; the nitrogen with which the apparatus was initially filled is simultaneously released from the level-control vessels at the top of the system.

The experimental apparatus consists of two separate 1in diameter pipe circuits, each with its own single phase electromagnetic pump, linked together by a small tube-and-annulus heat exchanger. The first circuit, containing pump *A*, is provided with an electric heater of about 100kW capacity ; the second, containing pump *B*, includes a cooler in which heat is rejected to water. A sketch of the tube-and-annulus heat exchanger is shown in Fig. 5 ; the hot liquid metal passes through the tube and the cooler liquid metal through the annulus. It has been possible to produce a heat flux through the wall of the tube of almost 1kW per square centimetre (approximately 3×10^6 B.Th.U. per square foot per hour). If this tube is of stainless steel, 0·020in thick, the heat flux corresponds to a conduction temperature drop in the thickness of the tube of about 250 deg. Cent. ; the consequent thermal stresses, based on elastic theory, are of the order of 40 tons per square inch.

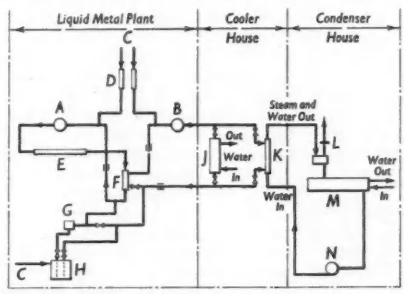
The water cooler is situated in an annexe to the main building so as to limit the amount of liquid metal and water which can come into contact in the event of an accidental leakage. The heat exchanger itself consists of separate banks of liquid-metal and water tubes bonded together by casting in a block of aluminium. An alternative cooler, consisting of a simple tube and annulus heat exchanger with boiling water in the tube, is also available.

Design and Operational Problems

The design of the various components which are common to most liquid metal circuits will now be considered in more detail.

Storage.—The first consideration in the handling of sodium and sodium-potassium alloys is the problem of storage. The alloys containing between 15 and 50 per cent sodium by weight are liquid above 10 deg. Cent. Outside this range there will at this temperature be a mixture of solid sodium or potassium and the eutectic (which contains 22 per cent sodium and freezes at −12 deg. Cent.). The supply of material for the present work consisted of solid sodium in the form of 3½ lb bricks packed in mild steel drums with airtight lids, and the liquid eutectic in mild steel carboys with screwed caps, each containing 112 lb. Alloys containing more sodium have been prepared and stored in the same carboys ; in this case it is necessary to heat the carboys above the temperature on the liquidus curve corresponding to the particular alloy before discharging.

The storage area should be dry and there should be no water supply in the building. A supply of dry soda ash or one of the proprietary



—▷◁— Valves shown on liquid-metal circuits only.
—A— Single-phase electromagnetic pump.
Electromagnetic flow meters.
Direction of flow.

A, *B*—Pumps.
C—Nitrogen supply.
D—Level control vessels.
E—Heater.
F—High flux exchanger (see Fig. 5).
G—Filter.
H—Reservoir tank.
J—Cooler.
K—Evaporator.
L—Safety valve.
M—Condenser.
N—Recirculating pump.

Fig. 4—Layout of high heat flux apparatus

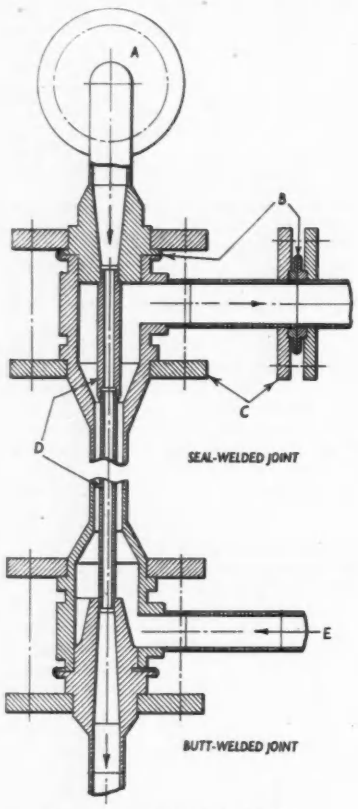
brands of fire-extinguishing powder for alkali metals should be readily available. It sometimes happens that if metal is exposed to a humid atmosphere before sealing in its container, a pressure of hydrogen is developed ; there is, therefore, the possibility of a hydrogen explosion if the container is opened near a naked flame. It is usual to provide shallow steel trays to contain accidental spillages, which are then dealt with by covering with soda ash and removing to a disposal area where they are burnt. Neither sodium nor sodium-potassium alloys will burn freely even in moist air unless heated above 100 deg. Cent.

Materials of Construction.—There is a considerable amount of information in the literature concerning the compatibility of various materials with sodium and sodium-potassium. (Sodium and the alloy are usually considered to be similar

in this respect.) The choice of materials is very wide provided that a temperature of 200 deg. Cent. is not exceeded (*Liquid Metals Handbook*, 1952). Mild steel is suitable for long-term use up to 450 deg. Cent., and for higher temperatures suitable materials include the austenitic and ferritic stainless steels, pure iron, nickel, inconel, nichrome, and the refractory metals niobium, molybdenum, tantalum and tungsten.

In the work described in this paper, an austenitic 18/8 titanium stabilised stainless steel was used. Although mild steel has been used for lower temperature work, stainless steel is in general preferable for experimental apparatus where it is necessary to open the circuit to atmosphere frequently without oxidation of the pipe surfaces.

Fabrication Methods.—An all-welded construction is recommended for long-term operation, since the choice of jointing materials to withstand alkali metals is strictly limited, and normal brazing materials are unsuitable. For short-term operation at temperatures up to 400 deg. Cent. a flanged joint with a soft copper joint ring may be used and for temperatures up to about 150 deg. Cent. various proprietary types of metal-to-metal coupling have been found satisfactory. The liquid metal possesses the doubtful virtue of sealing itself by oxidation against small leaks at low pressure and temperature.



Showing the methods of pipe jointing.

A—Hot inlet.
B—Seal welds.
C—Mild steel backing flanges and bolts.
D—Distance piece to adjust length of test tube.
E—Cold inlet.

Fig. 5—Tube-and-annulus heat exchanger for high heat fluxes

Extensive use has been made of the type of seal-welded flanged joint which is shown in Fig. 5. It is not recommended for general use since the number of times the weld can be removed and the joint resealed is limited to about three or four. The thermal capacity of the rather bulky flange is also an embarrassment when the pipe system has to be heated by electrical trace heaters before filling with sodium.

A butt-welded pipe joint is recommended whenever possible for the following reasons. First, it may be radiographed, and, secondly, the circuit may be opened by a saw cut and sealed again by a butt weld. Argon arc fusion welds are used, the pipe being filled with nitrogen before welding so as to prevent oxidation at the back of the weld. For larger welds a filler rod of the same material as the pipe is used, or, alternatively, the initial argon-arc weld is backed up by metallic-arc runs. Heat-treatment of the weld has been found unnecessary.

In the earlier stages of the work all welds were radiographed, but this condition is now relaxed on equipment for short-term operation. In the course of the whole of the work described in this paper, there has not been a single failure of a butt-welded joint.

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(To be continued)

Speeding Aircraft Production

At the fourth annual conference on "Problems of Aircraft Production," held by the Southern Section of the Institution of Production Engineers at Southampton University on January 6th and 7th, the first Lord Sempill paper was read by Sir Roy Fedden on the subject of "Britain's Aircraft Needs." Defining the nation's needs as an adequate air force and at least sufficient commercial types to meet its own needs, the paper suggested that the time and money devoted to military construction could have produced 2000 swept-wing fighters and 500 strategic bombers, but had actually yielded less than 600 fighters and fifty "V" bombers. Our air power was in the position of Poland's in 1939. A main line civil aircraft was so highly specialised that it could not be undertaken with any prospect of development in the required time by any except really large firms. One U.S. manufacturer expected to spend nearly £13,000,000 engineering a trans-atlantic airliner. The leading of a team to tackle such a job was a supreme test of ability, and one of the major problems of the industry was lack of experience of designing airliners. There was a particular dearth of mechanical engineers, and structures and aerodynamics were disproportionately strong in the design teams. This lack of manpower when working against a timetable resulted in punishing compromises.

Sir Roy traced the difficulties of the industry from immediately after World War II, when little attention was paid to the achievements of German research work. The easy-going and lazy nature of the British did not rise to the challenge of building new, slim, swept-wing aircraft. Similarly, the distressing trait of writing down and criticising new things because they are new, and maintaining a *blasé* attitude of boredom to any enthusiasm on fresh techniques, which is the pith of life in engineering, had led to the difficult position prevailing. Those responsible for planning had not produced the right answers, possibly because engineers did not sway the Ministry of Supply. On the record of the last ten years, the procurement of aircraft should be the work of the Air Ministry and not the Ministry of Supply. He was in favour of Royal Air Force technical officers co-operating with industry on technical planning, and held up as an example the organisation of Research and Development in the United States.

The technical failures of the post-war era were laid at the door of the chief engineers and senior executives in industry; because of the fluctuating requirements of the Government, firms had accepted work beyond their capacity. Also, they were more than a generation behind in supersonic flight because of the official decision to conduct researches with unmanned aircraft. Outside design firms were decried because of the need for enthusiasm and the personal interest in the product. British designers had not made the opportunity to investigate the invaluable services of machine computing, and it was hoped that the College of Aeronautics would train staff for such work. In spite of Britain having the best production technique for titanium, metallurgists had fallen behind, and the influx of foreign machine tools was causing concern.

The Royal Aeronautical Society was expected to take the lead in handling the new and profound problems existing, possibly in conjunction with the Society of British Aircraft Constructors. An entirely new plan for the future was needed. Too many major firms and military projects were stretching technical and engineering resources; only those projects really needed should be retained, and once ordered there must be no further looking over the shoulder.

A new and exciting prospect was that of making aircraft resembling a traditional engineering structure. The new aircraft could be produced in small quantities with short lead times, because extensive and costly special tooling would be superseded by techniques employing heavy-duty routers under automatic control. Only directing tapes and rudimentary fixtures would be special to type. This technique should allow the U.K. to excel, but the machine tool manufacturers were doing little about it.

In the final analysis the lack of the right type of trained human beings to organise and control the extremely exacting, but enthralling, business of aircraft engineering was the main cause why the nation's needs were not being met. This was largely because the status of engineering was still not equal to that of the classical professions.

In the subsequent discussion Mr. W. S. Hollis observed that only the highest quality machine tools would respond to automatic control; a sense of urgency in ordering tools was cheapest in the long run.

Mr. H. A. Chambers reported that the Americans had employed skin milling machines to make in one piece a wing that would normally have 1500 components, each with its own paper work.

It was pointed out by Mr. W. E. W. Petter that engineers were scarce and overworked. His theory was that the level of taxation prevailing in a Welfare State destroyed the incentive to excel.

The Rt. Hon. Viscount Caldecote considered that head teachers had not realised that the community was supported by the efforts of the engineers; the Government also appeared still to esteem a man without specialist training.

The leading critic of the paper was Mr. R. L. Lickley, who considered its opinions too gloomy. Since the industry was competing for engineers with other industries, continuous criticism was harmful.

Sir Roy, responding, suggested that the S.B.A.C. and the R.Ae.S. could initiate courses in detail draughtsmanship and its supervision with important benefits to the production engineer. Addressing Mr. Lickley, he drew attention to the prevailing habit of decrying developments in the U.S.A. only to adopt them later. He cited instances in which techniques originated in Britain had been applied first in the United States.

Summing up the proceedings of the conference, Lord Sempill remarked that Sir Roy Fedden, himself preceded by such engineers as Royce, Bentley and Coatalen, had at one time dominated the design of engines over the world, and that era had been ended by the agency of Sir Frank Whittle. He emphasised that the strength of 600 fighters and fifty bombers was entirely unsuited to an air force that had been a power in shaping the world.

He proceeded to observe that at such conferences as this, the papers should ideally be sent to those attending, in ample time for them to be studied, so that members intending to take part in the discussions could signify so beforehand. The papers would not be read aloud, the authors merely giving a précis at the meeting.

Three further papers were read and discussed at the meeting. That by H. A. Gregory and A. Vines, "Time Can Be Saved—in the aircraft industry," commenced by showing how violently the output of the industry had fluctuated in the years since 1914, and pointed out that, in the experience of the Fairey Aviation Company, it was not only quicker but also cheaper to send

goods from the London area to Canada, Belgium and Manchester by air than by surface transport. They described their organisation, in which design and production development proceeded in parallel on each component or group of components, and their adoption of jigs defining the outer surface of parts even for items other than aerofoils. The work of the machine tool division, particularly in attaining extreme metal removal rates from large castings or slabs of light alloy, was described and illustrated with details of high-speed milling heads. They were strongly in favour of complete programme control of machine tools.

A paper on "Control of Production Processes," by I. R. Smith, outlined the methods available for the control of materials and manufacturing processes. Dealing with recent developments in the United States, the lecturer described a tank 50ft by 25ft for applying the immersed scanning technique of ultrasonic inspection; a scanning speed of 18in per minute was attained. He mentioned that Douglas fighter aircraft were X-rayed completely when assembled, in order to check the internal "plumbing" and also the presence of foreign bodies. It was mentioned that dimensional errors in the products of automatic machining would be too small to justify inspection.

Finally D. A. Oliver, T. S. Lister, M. D. Kinman and D. Fitzgeorge, in a paper sponsored by the Machine Tool Trades Association, described some recent machining research, principally on high-strength steels. They had found that ceramic tools introduced unwelcome problems.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

NATURAL RUBBER JOINT RINGS FOR GAS MAINS, WATER MAINS AND SEWERS

No. 2494 : 1955. Price 2s.—This new British Standard replaces B.S. 674 "Rubber Joint Rings for Water Mains and Sewers" and B.S. 772 "Rubber Joint Rings for Gas Mains." The standard specifies six hardnesses of vulcanised natural rubber joint rings for use in mains containing such fluids as: town gas, coal gas, water gas, natural gas, water and sewage. Details of the material from which the rings are to be made are laid down, together with requirements for physical properties both before and after ageing. Limits are specified for swelling and water absorption, and sampling and marking requirements are given. The adoption of B.S. 2494 will make it possible for manufacturers to supply users with joint rings which are made for one or other of the specific purposes covered by the standard. In the past, manufacturers have not always been made aware of the services for which the joint rings were required.

ROUGHNESS COMPARISON SPECIMENS. PART I: GROUND CYLINDRICAL TYPE (PRIMARY TEXTURE)

No. 2634 : 1955. Price 2s. 6d.—A series of standards, of which this is the first, is now in course of preparation for surface finish reference specimens intended to represent different machining processes. The present standard deals with specimens of the ground cylindrical type exhibiting grades of primary texture ranging from C.L.A. 4 to C.L.A. 63; this range is thought to embrace the values most likely to be required and attained in ordinary cylindrical grinding. Requirements for dimensions and general design are specified and recommended methods of production are given. Notes on the application of the specimens are included in an appendix.

CORD-OPERATED CEILING-SWITCHES

No. 2652 : 1955. Price 2s. 6d.—This new standard covers commonly used cord-operated ceiling switches with a maximum rating of 5A and 250V. The switches are for use in substantially non-inductive a.c. circuits only, or in substantially non-inductive a.c. and d.c. circuits indiscriminately.

Definitions for the various types of switch are given in the first section of the publication and the second section gives the constructional requirements which apply to all switches for domestic and similar purposes; it also specifies the special requirements for the action and attachment of the operating cord.

Section 3 specifies the electrical tests, including current-carrying capacity, endurance, over-voltage and over-current capacity and high-voltage tests. Tests of mechanical strength and endurance, and of the maximum pull to be exerted on the cord, are also included. Requirements for marking are given in the final section.

International Definition of Concrete Mixes

ONE of the papers presented at the Fifth Congress on Large Dams, held in Paris last May and June, was a report submitted by the international sub-committee on concrete for large dams, entitled "Report on Frost Resistance of Concrete and of the Definition of Concrete Mixes" (paper R.70, question 19). This report is considered to have considerable general importance to the civil engineer and concrete technologist, extending beyond the sphere of dam construction, and so it has been published separately from the congress proceedings.* It consists of ten papers on various aspects of tests and investigations into the frost resistance of concrete, and an eleventh paper, prepared by the international sub-committee, entitled "Definition of Concrete Mixes Used in Dam Construction." It is pointed out that, in comparing a concrete described in one published report with that in another, difficulties are often experienced owing to the absence of relevant data. Recommended minimum data for: (*a*) a brief description and (*b*) a full report of concrete in a dam have, therefore, been prepared. It is expected that the adoption of these criteria will help international comparisons of concrete and will provide a valuable basis for recording concrete mixes. The two classes of data are given below.

MINIMUM DATA REQUIRED IN A BRIEF DESCRIPTION OF THE CONCRETE IN A DAM

(*a*) Cement content of finished concrete (in kilogrammes per cubic metre or pounds per cubic yard).

(*b*) Effective water/cement ratio (i.e. corrected for aggregate in the saturated, surface-dry condition).

(*c*) Type or types of cement with reference to any standard specifications applicable. (In the case of "blended" cements, the proportion by weight of pozzolana or other material present should be stated.)

(*d*) Broad petrological classification of aggregate, e.g. limestone, granite, &c., origin (i.e. crushed or natural), and maximum size employed.

(*e*) Method of compaction.

(*f*) Use of a workability aid or air-entraining agent.

(*g*) Estimated air content of finished concrete, whether entrained or entrapped, as a percentage by volume.

DATA REQUIRED IN A FULL REPORT ON THE CONCRETE IN A DAM

(1) *Cement.*—(*a*) Type or types of cement with reference to any standard specifications applicable. (In the case of "blended" cements, the proportion by weight of pozzolana or other material present should be stated.)

(*b*) Specific gravity of cement, e.g. as determined in distilled kerosene.

(*c*) Chemical composition of cement, including percentage of alkalis present.

(*d*) Properties of cement, including strength, fineness and heat of hydration. (The method of test should be briefly indicated with reference to any standard specification applicable.)

(2) *Admixtures* (*including workability aids, air-entraining agents, &c.*).—(*a*) Nature of added material.

(*b*) Amount of added material (usually in terms of a unit weight of cement).

(3) *Properties of Aggregate Materials* (*including sand or inert additions*).—The following data are required on the aggregate materials; where a concrete mix contains material from more than one source (e.g. where a natural sand from a pit or river deposit is used in conjunction with crushed rock from a quarry) the data should be given separately for each source of material, irrespective of any overlap in particle sizes.

(*a*) Petrological type and description, origin (i.e. crushed or natural), particle shape, and surface texture.

(*b*) Size distribution and proportion by weight of the total aggregate in the mix.

(*c*) Absorption of water by weight from the oven-dry (100 deg. to 110 deg. Cent.) condition to the saturated, surface-dry condition.

(*d*) Coefficient of thermal expansion of aggregate material (more especially for concretes exposed to frost action).

(4) *Combined Aggregate* (*as used in the concrete mix*).—(*a*) Maximum size of aggregate used.

(*b*) Complete grading analysis of the combined aggregate expressed in terms of "dry" weights.

(The grading analysis should cover the whole range of aggregate sizes down to the finest sand; it should include a statement of the percentage by "dry" weight of fine material passing the A.S.T.M. No. 4, or equivalent, sieve.)

(*c*) Absorption of water by weight, from the "dry" condition (i.e. as used in the grading analysis) to the saturated, surface-dry condition, of the fractions above and below the A.S.T.M. No. 4, or equivalent, sieve.

(The "dry" condition customarily used in the grading analysis may differ in different countries and may range from the oven-dry to the saturated, surface-dry condition. The data on absorption are necessary in order that the mix may eventually be expressible in terms of the absolute volumes occupied in the finished concrete.)

(*d*) Specific gravities in the saturated, surface-dry condition of the fractions above and below the A.S.T.M. No. 4, or equivalent, sieve.

(*e*) Method of batching (i.e. by weight or volume); size limits of the aggregate fractions which are batched separately.

(5) *Concrete Proportions.*—In the concrete mix.

(*a*) Aggregate/cement ratio by weight, stating whether the ratio is based on aggregate in the "dry" condition or has already been corrected for the saturated, surface-dry condition using the data already given.

(The proportion of aggregate passing the A.S.T.M. No. 4, or equivalent, sieve will already have been given.)

(*b*) Effective water/cement ratio by weight (i.e. corrected for aggregate in the saturated, surface-dry condition).

In the finished concrete (i.e. in the concrete in place in the dam after compaction but before any water loss through drying):

(*c*) Estimated cement content of the finished concrete (in kilogrammes per cubic metre or pounds per cubic yard).

(*d*) Estimated air content of finished concrete, whether entrained or entrapped, as a percentage by volume.

(*e*) Estimated density of finished concrete.

(These three estimated quantities are interrelated and will, in many cases, be based on the measured volume of the finished concrete as compared with the amount of cement used. They should be consistent both with each other and with the data already given on the mix proportions by weight and by absolute volume.)

(6) *Workability and Method of Compaction.*

(7) *Properties of Concrete and Quality Control.*

(*a*) Dimensions, preparation and curing of control cubes, prisms, or cylinders.

(*b*) Statistical variation in strength or of other properties measured.

(This should include the number of specimens tested, the average strength or other property measured and the coefficient of variation.)

(*c*) Method of removing the large aggregate from the concrete used for test specimens when aggregate above a certain size is excluded.

(*d*) Measured air content of mix, e.g. as measured on a sample of fresh concrete in an air meter.

(*e*) Measured density of mix, e.g. as measured on a concrete specimen.

GENERAL NOTE ON LIST 2

Care should be taken that sufficient of these data are included to permit calculation of the composition, in terms of the absolute volumes occupied in the finished concrete by the cement, aggregates, water and air, of both:

(*a*) The total concrete, and

(*b*) That part of the concrete material below the A.S.T.M. No. 4, or equivalent, sieve size (i.e. excluding the larger aggregate).

(Inclusion of the data under heading (*b*) provides for the possibility of comparing different concretes containing large size aggregates through the properties of their matrix mortars.)

Where the composition of the concrete by absolute volume has been calculated it should be given in addition to the more conventional mix data.

* The report is obtainable from the Secretary of the British Committee on Concrete for Large Dams, c/c Building Research Station, Garston, Watford, Herts. Price 10s.

Advanced Courses for Engineers in Industry

At a joint meeting of the Institutions of Civil, Mechanical and Electrical Engineers, held last Monday, January 16th, three papers were read under the general title "Advanced Courses for Engineers in Industry." In the papers courses of all kinds, ranging from those suited to graduates undergoing practical training in industry, through short-term specialist courses for more experienced men, to longer-term courses extending over several months, again for experienced men, are discussed. Excerpts from the papers are printed.

PART I: BY H. D. MORGAN, M.SC. (ENG.), M.I.C.E.*

THERE is some misapprehension as to the meaning of the word "education." It is too frequently considered that it should be vocational and no more. Scholarship for its own sake is no longer desired as it once was. Specialisation is on the increase and the demand for scientific and technical manpower is so great that the mind-training aspects of education are tending to be forgotten in the race to meet the ever-increasing demand for technologists. There is a need for individuals who can think on broad lines, and to supply this it is by no means certain that the technical training favoured to-day is comparable with the classical education of yesterday.

There is a great need for sensible technical executives as well as experts; that is, individuals with common sense who can shift their thoughts rapidly from one subject to another, can assess the claims of the experts, balance technical elegance against economy and, above all, deal with problems which are new to them and unrelated to their technical training. The importance in all problems of the common-sense viewpoint cannot be overstressed; in any system of education the development of this side of the student's mind should take an important place.

This introduction may seem at first sight a little removed from the subject of this paper but it is because specialisation is tending to appear even in universities and schools that the need for a broad treatment, of advanced courses is so great. At present technical knowledge accumulates far more rapidly than human wisdom increases; what is more, technologists sometimes seem the least aware of the real object of their work. This is a view that has been expressed before but it is ignored so often in technological education that its repetition may perhaps be pardoned.

It may be asked whether full use would be made of increased opportunities for advanced education. Human inertia is hard to overcome. Some consider that they need learn no more after leaving school or university, while others recognise the desirability of so doing but feel they have not the time available. In either case the fault lies more often with the individual than in the lack of opportunity. Present and possible future facilities only will be considered here, and it will be assumed that the desire to make use of them exists.

Before attempting a detailed survey of the present requirements for advanced courses for civil engineers and of the extent to which these can be met, it would be useful to consider the case of a typical graduate—or trainee with similar qualifications—who is embarking on his career and taking the measure of what he knows and what he can do. He will have acquired a broad idea of the general principles of the several branches of engineering and a more detailed knowledge of the branch which he has adopted—civil engineering in this case. He will have a mathematical grounding, some knowledge of geology, materials, structures and hydraulics; also of drawing and surveying. However, there is a notable list of subjects about which he will know very little but which occupy much of the practising engineer's time. These include preparation of reports; organisation and planning of work; preparation of contract documents; economics of design; quantities and measurements, and legal and labour problems.

In addition, there are associated subjects such as architecture, agriculture and welfare, for which the engineer is seldom directly responsible but which are often involved with his work.

Apart from these gaps in his knowledge the graduate finds that in spite of lengthy training he is not yet equipped to prepare designs and contract documents for works without a great deal of supervision. If, however, his education has been successful in teaching him to think clearly, his mind will be in a receptive state and he will be eager to fill in any gap, not only through practice but also by further personal study. There is thus a need for further education as soon as the young engineer qualifies. Later the more experienced engineer, now possibly approaching middle-age, will find new techniques and methods of design appearing which were not available in his university days. He will also find that he is forgetting subjects in which he has not happened to have had any opportunity of gaining practical experience. The author has nearly completed thirty years in the profession, almost fourteen of these being as a partner in a firm of consulting engineers. It has been found that men tend to fall into two main groups: those who seem to prefer and do better at administrative work and others who prefer the purely technological work. This tendency is so marked that it has often been found necessary to have two men working on parallel lines at the head of a section dealing with a specific work. It is believed that the reason for this tendency towards segregation is that on the one hand the individual who finds his technical subjects quite easy at the university, becomes wrapped up in them to the extent that he grudges the time to deal with the other aspects of the work, while another, who does not find his technical subjects quite so easy, finds his outlet in planning and organisation. The best and most valuable men are undoubtedly those who combine these abilities, but they appear to be rare.

It seems, therefore, that a valuable service could be rendered to the industry and the individual if means could be found for engineers of experience, not only to study new methods and techniques which have come into being since their period of training was completed, but also to enable them to study, if they wish, the aspects of their work which they find difficult to approach and thus, as it were, adjust the balance of their experience.

A list is given below of the subjects in which it is suggested courses of instruction would be valuable. The first main group contains subjects which arise in the administration of engineering work. The second main group concerns technical matters; that is, methods of design and the use of modern techniques.

Group I: Administration.

(1) Preparation of reports—structure and composition.
(2) Contract procedure.
(3) Preparation of estimates and make-up of costs.

Group II: Technical.

(1) Modern concrete technology.
  (*a*) Preparation of concrete:
    (i) Mix design.
    (ii) Quality control.
  (*b*) Concretes for special purposes:
    (i) "Zero slump" concrete.
    (ii) Resistance to frost and abrasion.
  (*c*) Ready-mixed concrete.
  (*d*) Use of additives.
  (*e*) Placing of concrete:
    (i) Transport by skip.
    (ii) Compressed-air placing
    (iii) Concrete pump.
    (iv) Placing underwater
    (v) Placing in cold weather.
    (vi) Vibration and revibration.
(2) Prestressed concrete.
(3) Welded steel structures.
(4) Aluminium alloys in structural engineering.
(5) Soil mechanics.

EXISTING FACILITIES

Having discussed the desirability of advanced courses, it now remains to examine the existing facilities and to see how far these meet the requirements. There is a fair number and variety of courses available in London and the other large centres at technical colleges and mainly in the evenings.

Table I shows the advanced courses for civil engineers which are available at the present time, either in London or in other parts of Britain. It has been found that subjects numbers 1–10 inclusive are the more common, numbers 11–15 more rare.

TABLE I—*Advanced Courses for Engineers*

1.—Foundations and sub-soils
2.—Soil mechanics
3.—Design of welded structures
4.—Modern structural analysis
5.—Structural stability
6.—Reinforced concrete (advanced)
7.—Prestressed concrete
8.—Shell concrete roofs
9.—Concrete technology
10.—Aluminium alloys in structural engineering
11.—Specifications and quantities for civil engineering contracts
12.—Elements of law relating to civil and mechanical engineering
13.—Organisation of civil engineering contracts
14.—Administration of acts controlling building
15.—Accountancy and costing

Although courses are available to a substantial proportion of the profession, there are many in isolated parts who cannot attend them at all, and even more who would have to undertake long and exhausting journeys to do so. For these there remains only the correspondence courses, which, although they have obviously given a useful service, can be little better than independent reading with a little direction and some discipline added. By their very nature and regardless of how well they are thought out and administered, they are clearly the least satisfactory form of education.

Evening classes represent a great improvement over correspondence courses, and it would be fitting here to make an acknowledgment to the technical colleges and polytechnics which are almost alone in providing these. In London especially they provide excellent courses on most of the new techniques such as prestressed concrete and soil mechanics, as well as a wide variety of lectures on the more basic subjects which could well be used as detailed refresher courses, although they are not necessarily intended as such.

In spite of the admirable work which they do, the technical colleges do not, except in isolated cases, meet the needs on the more general subjects not usually covered at the universities, and they do not give concise refresher courses to suit the executive who has already had a full technical education. Also, evening classes have inevitable drawbacks however well they are conducted. In the first place, the minds of the students and sometimes perhaps that of the lecturer are already tired by a full day's work; secondly, the courses are usually too extended—often a whole winter for a single set of lectures—with the result that uninterrupted attendance is rarely possible, gaps being caused either by illness or exigencies of the student's employment.

Whole-time studies for periods varying from, say, three days to three weeks could be preferable to evening classes for almost all advanced education, but at present the number of available courses of this type is very small indeed. Inevitably, such courses would interfere with the engineer's normal work, and his employer might well be unable to allow him a week or two of study time in any year in addition to his annual holiday, especially since those best fitted to benefit would probably be those least easy to spare. However, few men are indispensable and, if the practice of allowing study time were to come about gradually, the employer might feel that the benefits were equivalent to the disadvantages.

With such concise courses, the problem of mental fatigue associated with evening classes would be largely solved and the student would be able to concentrate his mind wholly on the subject during the period of the course. Further, the courses would become available to many of those living in comparatively remote parts who could not attend evening classes.

The universities, which at present do not provide for additional education later than their normal post-graduate courses, seem almost ideally placed to give concise advanced courses, especially those on the more general subjects. These could possibly be given during the vaca-

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tions, when lecture rooms would be free and when demonstrations could be arranged without interfering with routine laboratory work. Further, rooms and meals would often be available at reasonable rates for those attending. It is believed that many university lecturers would be glad to co-operate, and such courses might also help the residential colleges by giving more regular employment to their other staff throughout the year. Apart from the universities, certain of the government technical departments and trade associations might well provide courses. Such an association has recently sponsored a most valuable symposium on concrete technology.

Recently also the Building Research Station and Road Research Laboratory have been holding "open days." These might be extended to include brief courses of lectures which would perform the additional service of bringing the research staff in such establishments into still closer contact with the industry.

There is no reason why the technical colleges and polytechnics should not also give short full-time courses, but it might be more practicable for them to concentrate on broadening the range of their evening classes to cover a wider variety of subjects. This would be attractive to those unable to spare the time for full-time study and also to those who wish to take, perhaps, two or more courses in a year.

The cost of such courses should be kept as low as practicable. If it were possible to provide a measure of financial assistance, this would certainly encourage full utilisation. Certain branches of industry have recently shown considerable generosity in similar circumstances and it would be reasonable to hope for some help from this direction and possibly from the Government which, owing to its several commissions and authorities, must now be interested more than formerly in this subject.

PART II: BY PROFESSOR G. F. MUCKLOW, D.SC., M.I.MECH.E.†

Post-war conditions have made it clear that Britain, unable to produce food for her huge industrial population and handicapped by declining natural resources, must increasingly depend for her well-being on an expanding level of exports of engineering products of all kinds.

It is equally clear that the effectiveness of these products must be measured, not by mere weight or volume, but in terms of the technical skill and brain power embodied in each pound of material. In fact, the sole hope of combating growing competition from overseas lies in better craftsmanship, improved methods of production, more advanced design, and greater imagination and initiative in the application of scientific thought and discovery.

The matter thus resolves itself essentially to one of education and training, there being two separate problems involved. The first is that of increasing, at each level, the number of young men entering the engineering industry and of providing suitable facilities for their basic education and training. The second problem, that of maintaining and increasing the technical efficiency and professional ability of those actually engaged in engineering, involves both a short-term and a long-term requirement. The former is to ensure the rapid dissemination throughout industry of the latest knowledge and information regarding new methods and techniques, so that those concerned shall be kept continually abreast of each fresh advance and development. Of no less importance is the long-term necessity of providing for future technical leadership. This demands that throughout industry, young engineers of particular promise should be picked out for special training, so that to their knowledge of the practical aspects of their chosen fields may be added a thorough understanding of the related fundamental scientific concepts and of the possibilities and limitations thereby dictated.

The first of these problems has formed the subject of a profusion of reports and papers. The second problem—that of providing for continued engineering education and training—has attracted comparatively little attention and, perhaps for this reason, its importance has not received the widespread recognition it deserves. It is indeed little exaggeration to say that, except in so far as its short-term aspects are concerned, engineering firms in general remain as yet unconvinced of the existence of the problem and still less of its urgency. This outlook, indeed, forms a serious difficulty, since, given the whole-hearted interest and support of industry, the solution of the problem would not be far to seek. The simplest and most efficient method is undoubtedly to build on the existing educational system, and to increase the number and range of advanced courses of the types already offered by a number of university engineering schools and technical colleges.

The duration, the subject and the level at which that subject is treated must obviously depend on the circumstances and, in particular, on whether the objective is of a long-term or of a short-term nature. Thus, if the requirement to be met is a short-term one, the course is likely to be of short duration and narrowly specialised. For instance, when the object is the dissemination of information regarding some specialised technique or method, for the benefit of an individual firm or group of firms, the course may well consist of a series of evening lectures given at the neighbouring technical college. For other, but still short-term requirements, as, for example, the "refresher" course or the course for specialists, designed to cover some limited aspect or application of their own speciality, a full-time course of a few days, a week, or even longer may be suitable. The arrangement of the course may vary from a few part-time lectures to a carefully organised residential summer school. The range of topics appropriate to such courses is well-nigh inexhaustible and the levels at which those topics are treated may differ widely. In the majority of cases, however, courses of the short-term type will be planned to cater for the more immediate needs of industry and to deal with matters closely related to contemporary problems of design and manufacture. It would seem, therefore, that, in general, the organisation and conduct of such courses is a duty best undertaken by the technical colleges, by virtue of their situation in close contact with industry and of their ability to draw upon engineering firms and similar organisations for assistance in the matter of staff.

It does appear, however, that the shorter the duration of the course, the more specialised must be the subject dealt with and the more superficial the treatment of that subject. On the other hand, the benefits resulting from the short-duration course are quickly felt and, at the same time, no prolonged absence from their normal duties is incurred by those attending. If only for these reasons, also, it is to be expected that courses of this type should appear more attractive to industry and should therefore be less difficult to establish than when the object of the course is of a more long-term nature and its duration correspondingly increased.

Although, particularly for purposes such as the spreading of information regarding contemporary practice, short courses of the kind referred to are not only of the utmost value but are indeed a necessity for the continued health of industry, the need which they serve is of an immediate and short-term character. They are essentially different from, and can in no way replace, the full-scale graduate course, where the object is to cater for the future rather than the present. From the long-term point of view, the imperative need for this type of course cannot reasonably be disputed. To retain supremacy in world markets demands that in each specialised branch of engineering there should be young men of special promise coming forward who are equipped to form the spearhead of future progress. To keep abreast of the rising tide of knowledge, to be able to interpret and to apply each fresh advance and new development as it arises, requires from these men something more than the complete mastery of the accepted methods and techniques in their own fields of endeavour. They must possess also a deep insight into the theoretical aspects of those fields, coupled with the breadth of vision springing from a thorough familiarity with advanced concepts in other and related spheres of pure and applied science. The acquisition of this fundamental knowledge can result only from full-time study undertaken under suitable guidance and in an atmosphere freed from the distractions of industry.

To locate and collect from widely dispersed sources the information he requires and to study, unaided, completely new subjects, involving unfamiliar notations and treatments, can only represent to the engineer engaged in the routine of his profession an intolerable addition to his normal duties. The solution lies in the provision of carefully planned, full-time, courses of instruction, to which a relatively small number of selected young men may return after having achieved some measure of responsibility in the appropriate industrial sphere. By this means only can such men be provided with the requisite opportunity to study in an organised and intensive manner the advanced concepts and techniques in their own and related fields.

In certain of the larger engineering concerns the thought has arisen that courses of the nature considered might well be conducted internally by staff members of the organisation itself, some of them perhaps appointed for this especial purpose. This suggestion, though offering a possible means of satisfying immediate needs for courses of the short-term type, is wholly unsatisfactory where the intention is to provide balanced facilities for properly directed study in a range of subjects at really advanced level. For such courses fully to achieve their purpose no half-measures will suffice and both the highest possible standard of teaching and an adequate allowance of time are essential. The detail planning of an appropriately balanced syllabus and the preparation of the required series of lecture courses at the level envisaged is a matter not to be undertaken lightly, and certainly not as a part-time addition to other work. To teach at advanced level requires in the teacher himself the habit and background of study at advanced level. To choose well the syllabus appropriate to a course of the type considered demands a certain detachment of viewpoint and freedom from the bias of immediate commercial interest. It is one thing for a member of an engineering firm to deliver a single paper or a few lectures on some subject closely related to his daily work; it is quite another to expect him to undertake serious teaching in a range of subjects of a fundamental and theoretical character. From every point of view this duty is better left to experienced members of the teaching profession, working in the atmosphere of an institution created for the specific purpose.

The type of educational establishment best fitted to undertake the courses in view must depend on the particular circumstances, and no hard-and-fast rule can be laid down. It is recognised that the organisation and conduct of graduate level courses forms an activity which may with advantage be undertaken by certain types of college and institution other than the universities. The task is, however, essentially one for which the universities are pre-eminently well fitted, and it is envisaged that the organisation of advanced courses of the long-term type is a duty which will normally be their concern. It is indeed for exactly this purpose that graduate schools in selected branches of engineering science have within recent years been established in association with a number of university departments of engineering.

The situation of these graduate schools within a university, in proximity with established schools of pure and applied science and in an atmosphere permeated with the fertilising influence of research, is peculiarly appropriate to the function which they are designed to discharge. Courses at the level and of the quality envisaged are not possible except on the basis that teaching and research must go hand in hand. The graduate school should therefore operate in close contact with the existing school of research which forms an essential part of any university engineering department of standing and repute. Although the two schools should normally share the same field of interest, the work for which they are designed is, however, essentially different in character.

Since the expressed aim is to cover a range of subjects related to some chosen field of engineering, rather than a single topic, at a level which must inevitably call for sustained hard work on the part of the student, the courses given in these schools must necessarily be of relatively long

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duration. The habit of concentrated study is not immediately redeveloped after a break of some years. To establish a common starting level in a group of graduate students would necessitate a period of acclimatisation, even assuming each individual to possess a basic education in engineering science of identical standard and scope. Experience shows, in fact, that to achieve fully the purpose of a course of the type considered, where the aim is essentially of a long-term character, a duration of some nine to twelve months is essential. If results of real and lasting value are to be obtained, this fact must be faced. To reduce the above period or to substitute a series of short courses, each dealing piecemeal with a single topic within the chosen field, is to preclude close study of the relations between those topics and to defeat a primary object of the course. The courses themselves should normally comprise formal lectures, tutorial classes, and laboratory work, the latter being designed to illustrate the treatments developed during lectures to permit experimental confirmation of the results of mathematical analysis and theoretical argument and to afford familiarity with modern techniques of instrumentation. The general orientation should be towards the scientific approach, and the courses, although restricted to the chosen field of engineering science, should be in no way specialised in the narrow sense. Detail matters of engineering design and practice are suitable only to be treated adequately at advanced level by men in day-to-day contact with industry and, as such, should be avoided.

Although the establishment of graduate schools of the type considered offers to the engineering industry a long-term investment which cannot fail eventually to yield handsome dividends, there remains a formidable difficulty to be overcome. However well-planned the courses and however appropriately chosen their individual fields of interest, the success or failure of the scheme must ultimately depend on the degree of support and co-operation received from industry itself. Thus it is unlikely that a young engineer in industrial employment will be able to return to the university to attend a graduate course without the support and encouragement of his employers. He will in any case be reluctant to do so unless satisfied that his immediate seniority will not be prejudiced and that his ultimate prospects will be enhanced. It is also but natural that a senior engineer should be reluctant to lose a promising junior for some nine to twelve months without clear proof of the solid value and worth of the course it is proposed that he should attend. The establishment of graduate schools is admittedly a new venture and, for a time, it will be difficult for that proof to be given. Courses of the type considered, where the duration is comparatively long, the output of students relatively small, and the expressed purpose essentially of a long-term character, cannot be expected to produce their full effects on industry immediately. For their worth to be proved beyond doubt and for the proof to attain wide recognition, both time and an assured flow of students of the right quality are necessary. In the meantime there lies the difficulty that for these courses to prove their value a supply of students is essential, whilst until that proof is forthcoming industrial concerns may hesitate to lend their support. In terms of men, that support represents the release for a few months of but a minute proportion of the graduate engineers in employment, and, in relation to the potential long-term benefits, the cost to industry can only be regarded as infinitesimal. To a university, on the other hand, the maintenance of a graduate school of first-class quality represents a relatively heavy commitment which is unlikely to be continued for long without evidence that the full co-operation of industry will eventually be forthcoming. It is for this reason that the interest and backing of engineering firms and of the Government establishments during the early stages of the scheme is particularly desirable.

In certain quarters the fear has been expressed that to release a specially promising young man to attend a course of the type considered is to invite his thereafter being attracted to other employment. That this fear should be realised, however, is unlikely except as a result of the sense of frustration in one who, after arduous and concentrated efforts to improve his knowledge and ability, finds that no use is made of his added powers. The remedy is obvious and indeed, in the wider view, the transfer in such circumstances of a good man from one firm to another involves no loss to industry as a whole and may even prove to its advantage. The argument quoted above has been used in the past in relation to the provision of facilities for the practical training of engineering graduates. Thus, to the short-sighted view, it appeared unreasonable that trouble and expense should be incurred in training young men for the possible benefit of other employers. Time and the lead given by certain far-sighted engineering firms have shown the unwisdom of this attitude, with the result that to-day excellent opportunities for the acquisition of practical training and experience are available, to the undoubted benefit of industry as a whole. As in this case, so in others. The one factor which above all else will decide the position of British engineering in relation to its competitors in ten or fifteen years' time is the quality of the young men of promise now coming forward, who will then be in control. In the long-term view the preparation of these men for future leadership is a matter of supreme importance which deserves careful thought and constructive planning. Any steps taken now to improve their abilities and powers will yield future benefits out of all proportion to the temporary effort and inconvenience involved. Of the means available to this end, not the least important is the development of the full potentialities of a comprehensive system of advanced courses of instruction of the types outlined in the foregoing remarks. The task is one which calls for concerted efforts on the part of the university schools of engineering, the technical colleges and engineering firms. Each of these has an appropriate part to play, but it is abundantly clear that no efforts on the part of the two former bodies can be of avail without the active support and co-operation of industry itself.

Part III: Part-Time and Short-Duration Full-Time Courses

By Willis Jackson, D.Sc., D.Phil., M.I.Mech.E., M.I.E.E., F.R.S.‡

The Scheme of "Post-Advanced Lectures in Electrical and Mechanical Engineering" Organised by the Manchester and District Advisory Council for Further Education

Most of the large technical colleges in Britain arrange courses of lectures and laboratory work in extension of those constituting their Higher National Certificate courses. These are repeated from year to year and satisfactory completion of a group of them, occupying several evenings per week for one year, lead, for past students of the college, to the award of the Associateship of the college. They are frequently attended by university graduates who wish to extend their knowledge in particular branches of engineering science.

The foundation in Manchester in 1936 of the Regional Advisory Council for Technical and other forms of Further Education (now known as the Manchester and District Advisory Council for Further Education) led to consideration of the need in that area to supplement these provisions by short, non-recurrent, courses of lectures dealing with recent developments in specialised fields of engineering work for the benefit not so much of students, as normally understood, as of experienced practising engineers. The discussions within the Advisory Council resulted in the setting up of an Engineering Advisory Committee composed of representatives of the local technical colleges, university and industry and of the Institutions of Electrical and Mechanical Engineers, and to the introduction in 1938 of a scheme of Post-Advanced lecture courses. A particular feature of the scheme, which has proved of great merit, is that of associating with each course, as organising lecturer, an acknowledged expert in the subject, with the responsibility for choosing his associate lecturers and of ensuring that their respective contributions are properly co-ordinated.

The subjects and durations of the courses arranged for the 1955–56 session are given in Table I and are representative of the arrangements in previous years.

‡ Director of Research and Education, Metropolitan-Vickers Electrical Company, Ltd., Manchester.

Table I—*Post-Advanced Courses for Session* 1955-56

Subject	No. of lectures
At the Royal Technical College, Salford	
Steam turbines	11
Aircraft stressing	12
Fuel efficiency and heat conversion	9
The development and utilisation of modern mining electrical equipment	9
Electrical equipment of aircraft	8
Modern railway signalling	8
Field plotting techniques in engineering studies	8
At the College of Technology, Manchester	
Work study	8
Pressure vessels	8
Cooling towers	6
Linear network synthesis	6
Colour television	8
The application of digital computers to accountancy, costing and managerial control	8

Short Duration Full-Time Advanced Courses

Part-time courses of the type discussed in the preceding section suffer from the limitations that they afford inadequate opportunities for effective discussion and that they cater only for a local demand, whereas particular subjects may be of much more widespread interest and importance. These restrictions are removed by the alternative arrangement of a full-time course of a few days' duration which may be attended by men drawn from the country as a whole. A number of such courses have been organised by the Electrical Engineering Department of Imperial College of Science and Technology during the past few years, their subjects being :

Power system analysis.
Electrical machine analysis.
The insulation of electrical equipment.
The electrical equipment of aircraft.
The application of computers to the solution of engineering problems.

Each of the first four courses was of five days' duration, and the fifth of ten, and the attendance of about seventy persons in each case was drawn in varying proportions, and mainly by nomination, from manufacturing industry, electricity supply, government establishments, and the universities and technical colleges. The lecturers were mainly from outside the college and the procedure adopted was to invite their co-operation some eighteen months prior to the proposed date of the course. During the intervening period a succession of meetings was held for the purpose of defining the scope and content of the individual lectures and of ensuring that the subject matter of these lectures was available for circulation to the intending participants a month or so before the commencement of the course. In consequence, they were able to come well prepared for the discussion periods of which the course was mainly composed. These provoked extremely valuable exchanges of experience and opinion and, on occasions, led to the clarification of important technical difficulties. The content of the first and third of the courses appeared subsequently in book form and is therefore available for the benefit of future students of these subjects. In the author's opinion there is much scope and need for more courses organised on these lines.

Staff Courses

It is a big step from satisfying the examination requirements of one of the professional institutions to the attainment of senior executive positions on the design, research, manufacturing, commercial or operating sides of engineering work, and this involves much more than profitable participation in a training scheme and in courses of the types described above. The only effective way of ensuring that a man can carry responsibility is to put him in a position where he is obliged to carry it. In no other way can he demonstrate convincingly the possession of certain essential personal qualities and abilities. When this has been demonstrated by success in one situation, he will be tested and matured in others of greater complexity, with the advice and example of his more senior colleagues to guide him.

Nevertheless, a great deal of thought has been given during the post-war period to the question of whether anything can be done outside the immediate environment of employment to assist

this process. Can anything be done, for example, to develop a man's ability to appreciate the significance to his own work of the activities of others working in related fields; to organise co-operative effort among men of whose respective specialisms he may have only limited detailed knowledge; to draw reliable deductions and make sound decisions on inadequate evidence and in insufficient time; and to represent the views of other people, as well as to express his own, clearly and concisely.

Many experiments have been made during recent years in the attempt to seek answers to this kind of question, and it will help to focus discussion if a recent example is cited of a staff course of two weeks' duration for a group of twenty-four men in the age range 28–40, drawn from the research, design, manufacturing, sales, accounting, and overseas sections of a number of associated electrical companies. The aim of the course was not to instruct, so much as to enable the participants to compare their experiences and opinions and to evaluate these against a wider background than that of their individual environments.

For this purpose the topics chosen for consideration were, in the main, ones of which the members collectively had considerable experience in a variety of situations, and these were studied by the "syndicate" method. The twenty-four men were divided into three groups of eight men, each representative of as diverse a range of experience as possible, and to each of which an experienced tutor was attached. The tutor's function was that of consultant rather than of instructor, and to advise and guide, not to direct, his group's discussions. The composition of the three syndicate groups remained unchanged throughout the course, and each member acted as chairman for the consideration of one of the chosen subjects, and secretary for another. For each subject, the groups were supplied with a brief and referred to relevant reading material; they were also addressed collectively by a visiting speaker who later participated in the final conference on the subject. At these conferences the three relevant syndicate chairmen outlined the agreed or contradictory views of their colleagues on the subject in question, and these opening speeches were followed by the general discussion of an agenda which had been prepared by the chairmen and secretaries of the syndicates in consultation with the three tutors.

The time-table for each syndicate subject comprised two syndicate meetings, the address by a visiting speaker followed by a discussion, a third syndicate meeting and the final conference, each of one and a half hours' duration. The aggregate time of seven-and-a-half hours was supplemented for the syndicate chairman and his secretary by that occupied in private reading, consultation and the preparation of scripts. Special importance was attached to the last of these activities, and this accounted for the inclusion in the programme of the subject "The Spoken and Written Word," and for the considerable time devoted to it. The topics chosen for syndicate discussion included company organisation, wage structures, productivity, trade unions and employers' associations. Uses and limitations of the figures normally presented to and used by management, and economic background. Many other allied subjects would no doubt have been equally well suited to the achievement of the objectives discussed above. Arrangements were also made for talks on related matters by senior executives of the organisation, or by experts from outside it, and for subsequent discussion of them by the course members as a whole.

Only after a long succession of these courses will it be possible to make a reliable assessment of the benefit accruing from them, and the author would welcome the opinion of those who may have more extended experience of their organisation.

CEMENT PRODUCTION IN 1955.—The Cement Makers' Federation states that Portland cement production for the year 1955 amounted to 12,500,000 tons, of which 10,750,000 tons were delivered to the home market. Both these totals are the highest recorded, showing increased production and home deliveries for the tenth consecutive year.

Continental Engineering News

An Ultra-Microtome for Electron Microscopy

For the preparation of thin sections for optical microscopy microtomes have been in use since the eighteenth century. The thickness of the specimen required is related to the optical resolving power which, for the microscope, is of the order of $\frac{1}{2}$ micron to 1 micron ($0{\cdot}5$ to $1{\cdot}0\times10^{-3}$mm). Some modern microtomes are able to produce sections down to 1 micron.

The image in an electron microscope is formed in a different way, namely through variable scattering of electrons as they pass through parts of the object which differ in density. However, the criteria for the permissible thickness of the object are similar to those for the optical case. The object must be thin enough to transmit sufficient electrons of the energy employed (usually 50keV to 100keV), and also thin enough to avoid too many details piling up one behind the other. This latter condition is the more important, since if it is not fulfilled, the electrons may be scattered to such an extent that the image is blurred beyond possibility of interpretation.

With present-day electron microscopes which have powers of resolutions of the order of 50Å, sections of a thickness of 200Å or less are required. In microtomes of classical design, the specimen is advanced between successive cuts by means of a screw motion. Variations in the thickness of the oil film between mating surfaces impose a limit on the accuracy of such instruments, and although specimens of 1μ (10,000Å) can be cut in a reproducible fashion, this thickness is still far too high.

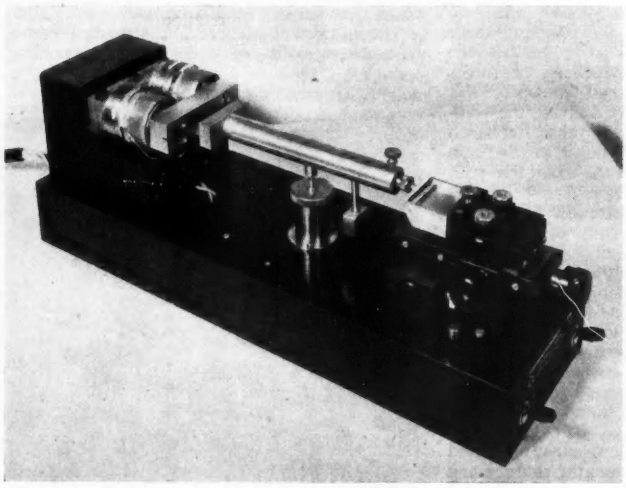


Fig. 1—Ultra-microtome for cutting specimens down to 100Å thickness or less. The cutting action is by magnetostriction and thermal expansion

Fig. 2—Aluminium specimen prepared by means of microtome shown in Fig. 1. Magnification about ×12,000

The lack of suitable ultra-microtomes for a long time limited the application of electron microscopy to the study of naturally small and very thin objects, and to that of very thin films. The technique of studying a replica of the object in the shape of a collodion or splutter-deposited gold film is well known. Besides being inapplicable in some fields, such as histology, the method is open to the objection that some of the details observed may be due to the film structure and not to the original.

Through refinements in the classical design in recent years, it has become possible to reach thicknesses of the order of 1000Å, and subsequently of 200Å. More recently an ultra-microtome has been developed in the Philips Laboratories at Eindhoven, which is capable of cutting slices 100Å thick or less. The instrument, which is illustrated in Fig. 1, is remarkable for its simplicity.

In the Eindhoven design the specimen is carried at the end of an arm, the other end of which is supported by a flexure pivot, thus avoiding all rolling or sliding movement. During the cutting stroke of about 3mm the specimen descends under gravity and spring force against the resistance of an oil dashpot. The return stroke is accomplished by lifting a permanent magnet (seen attached to the arm near the specimen holder) by means of a solenoid situated in the base of the instrument.

Cutting is done by a knife made of steel, glass or diamond, fitted in the side of a trough which is filled to the level of the edge with a liquid (usually 20 per cent alcohol) on which the cut specimens collect in the form of a chain, and from where they can be transferred to a "formvar" film on a specimen holder. After each cut the specimen must be retracted to avoid touching the knife blade during the return stroke, and must be advanced before the next cut is taken. Both these movements are accomplished by a combination of magnetostriction and thermal expansion of the spring pivot base, which is in the shape of two solenoid-wound nickel rods. When the solenoid current is switched on, magnetostriction retracts the specimen, and at the same time the heat energy dissipated in the coils is transmitted to the core as a small thermal impulse. Both the lifting solenoid and the base solenoids are supplied with direct current from a motor-driven commutator, so that a series of cuts can be taken automatically at the rate of about one per second. Owing to the comparatively large mass of the nickel cores, the thermal impulses average out and give the effect of a continuous expansion. Release of the magnetostriction, after each up-stroke, then moves the specimen to its new cutting position. Since the heat dissipates and hence the expansion is independent of the commutator speed, the thickness of the cuts can be varied by altering the number of cuts per minute. Alternatively, the current in the magnetostriction coil can be varied. Measurements of the displacement of the specimen holder, without cutting action, under the influence of magnetostriction and thermal expansion, in a twenty-minute test, gave an average thickness of 80Å per slice, varying in a systematic way by $\pm$10Å. Fig. 2 shows a section of aluminium prepared by this method.

Roots Vacuum Pump

For achieving the highest degrees of vacuum use is made of diffusion pumps, mostly of the oil-filled variety. Such pumps can reach pressures of the order of 10^{-6}mm Hg, and by

virtue of their very high pumping speeds, can maintain low pressures against the liberation of occluded gases within the system. In order to operate at all, however, diffusion pumps require a fore-vacuum of 10^{-1}mm Hg to 10^{-3}mm Hg, lower fore-pressures being required for lower ultimate pressures.

The practice of using oil-filled mechanical pumps such as rotary vane pumps, has the disadvantage that these pumps operate with a reduced efficiency below about 10^{-2}mm Hg. The reason is that in the compression space of such pumps, where the pressure is near-atmospheric, some gas is absorbed in the oil and gets carried into the vacuum space. The trouble is alleviated by using two mechanical pumping stages.

A more complete remedy has been found by developing rotary pumps which do not use oil. Pumps of this design based on the Roots principle, have been built by W. C. Heraeus, Hanau, German Federal Republic. Since no lubricant is to be used in the pumping space itself, a small clearance has to be left between the flanks of the rotors and between the rotors and the casing. At normal pressure, this clearance would substantially decrease the volumetric efficiency but within the range for which these pumps are intended, 10^{-1}mm Hg to 10^{-3}mm Hg, owing to the increase of the mean free path the back-leakage is negligible.

The accompanying illustration shows a pump with a nominal capacity of 1600 cubic metres per hour, which requires backing by a rotary vane or rotary piston pump to a pressure of under 10mm Hg. As backing pump, one with a pumping speed of about one-tenth that of the Roots pumps or 160 cubic metres per hour, is employed. The ultimate vacuum which can be achieved depends on the quality of the fore-vacuum. With a low fore-vacuum or with several Roots stages, pressures of 10^{-4}mm Hg to 10^{-5}mm Hg are possible.

The pump comprises two long vanes machined to the correct gear-tooth shape, the shafts being connected by gear wheels to keep the vanes in synchronism and with mutual clearance as

Roots intermediate vacuum pump, 1600 cubic metres per hour. Length 975mm, weight 185kg, power 1kW, three phase, 42V

stated. The vanes are situated in an inner housing which is kept free of oil. In order to avoid sealing difficulties at the high rotational speed of 3000 r.p.m., an outer airtight housing encloses the inner one. In the intermediate space which is connected to the fore-vacuum are situated the gear wheels, the electric motor and a small worm-driven oil pump for lubricating the bearing and gears. The squirrel cage rotor sits on the overhanging right-hand shaft end of the top vane, surrounded by a three-phase, water cooled stator. Power requirements are 1kW and in order to avoid flashing under vacuum, an operating voltage of 42V is used, which is obtained from a transformer.

Since internal friction is so small that a pressure differential of only 1mm Hg will set the pump rotating on its own, it may be left idling in the circuit while the fore-vacuum is being established. As soon as this is done, a built-in vacuum switch sets the pump motor going. Although this leads at first to a steep increase in pressure between the Roots pump and the fore-pump, if the fore-pump is of the correct size, the Roots pump is fully capable of withstanding the overload for the short time necessary. The pump is remarkably quiet in operation.

Infra Red Installation at Railway Station

Bremen has moved to break with the tradition of freezing temperatures in railway stations. At the Columbus Station, an infra-red heating installation of 450kW has been provided by A.E.G., consisting of 189 "dark" radiating elements in the form of tubes fitted under the ceiling, as illustrated below. Heat radiation from such tubes is not accompanied by any visible glow. There is hardly any time-lag after switching on and no wastage due to heat stored in the elements being given out after switching off. This point is of particular importance, as the station is mainly used early in the morning by passengers in transit from ships to the trains and vice versa, so that heating is only required during the short time needed for customs and immigration control.

The authorities had previously made attempts to ameliorate the conditions at this important terminus. When ships were due to arrive, a steam locomotive was used to supply a heat exchanger from which warm air could be delivered by means of ventilating fans to the main hall, which is used as a waiting room as well as giving access to the customs and luggage departments. It was found, however, that forced convection of warmed air was inadequate, since the walls of the building are not insulated and cold air is drawn in constantly through the large doors. Infra-red heating, on the other hand, is but little absorbed by the air and the energy can be concentrated by means of reflectors to where it is required.

The ceiling of the main hall at Columbus Station, Bremen, has been equipped with infra-red heating tubes

Copenhagen-Malmo Road Project

On December 2, 1955, two lectures were given before a joint meeting of the Society of Danish Engineers in Great Britain and Ireland and the Society of Swedish Engineers in Great Britain. In those lectures, Mr. B. Ekelund (Stockholm) and Mr. K. Höjgaard (Copenhagen) gave résumés, respectively, of the design aspects of the proposed road connection between Copenhagen and Malmö (the so-called Oresund Bridge project), and the financial and economic considerations which obtain. It was in 1936 that a consortium of three Danish and three Swedish firms first proposed a practicable design for carrying a road bridge from the island of Amager (on which lie parts of Copenhagen as well as Kastrup airport) over the Drogden fairway to the island of Saltholm and thence to the Swedish coast near Malmö. The proposal was considered at the time by the two governments, but no decision had been reached when the outbreak of war caused the scheme to be shelved indefinitely.

A revised scheme for the crossing was submitted by the same firms in January, 1954, and this is still being considered by a joint Danish-Swedish committee.

The new proposal differs from the earlier ones by calling for a two-lane roadway, with separated lanes, each 23ft wide, in place of a single-lane road 28ft wide. Moreover, since objections have been raised to a bridge structure in the vicinity of Kastrup airport, the crossing to Saltholm is now to be carried out as a tunnel.

From a proposed road linking Kastrop airport with the centre of Copenhagen, the new road is to branch off to the north of the airport and run for about two-thirds of a mile along a bank extending from the coast, before descending into the 2-mile tunnel to Saltholm. It will pass across the island above ground, a stretch of 2 miles, and then continue over a bridge 4 miles long spanning the Saltholm, Flint and Trindel channels to a point immediately south of Limhamn, on the west coast of Skåne, a distance of 6 miles altogether. From coast to coast the crossing will therefore be some 11 miles long. The distance on the road between the centres of Copenhagen and Malmö will be about 24 miles, to be covered in forty to fifty minutes' driving time.

The highest point of the bridge will be the 983ft span over the Flint channel, which will be 164ft above sea level and give 147ft clearance. Parking facilities for sightseers will be provided near this point. Over the Saltholm channel a span of 260ft length and 50ft clearance is projected, while the Trindel channel is to be bridged by a 665ft span with 80ft clearance.

By building the tunnel at sufficient depth it will be possible to increase the depth of water in Drogden fairway from the present 26ft to 40ft. Ventilation is to be by fan aggregates placed in three ventilation buildings spaced at distances of 2900ft, which are to rise 60ft above sea level. This, it is thought, allows sufficient room for manœuvre in the 1000ft wide fairway.

No provision is made for a railway connection, which, it is thought, would not prove economical, while the road, it is hoped, would be self-supporting within a few years. Costs (excluding interest) were estimated in 1954 at about Swedish kronor 300 million (£20,000,000). For preparatory work one and a half to two years are said to be required. This would be followed by five years of actual construction, so that the total time required for the scheme would be six and a half to seven years.

The Danish-Swedish traffic is now handled by ferries and passenger boats. While 70–80 per cent of the bridge traffic is expected to be local traffic, the project has great importance internationally. Putting the annual cost of operation at £200,000 and interest at £1·1 to £1·2 million, and basing calculations on a toll equivalent to 16s. per vehicle, about 1·6 to 1·8 millions of vehicles would have to do the crossing each year for the scheme to become self-supporting.

Industrial and Labour Notes

Employment and Unemployment

The Ministry of Labour's monthly report on the employment situation in Great Britain deals with the month of November last. It states that at the end of the month the number of people in civil employment was 23,106,000 (15,225,000 men and 7,881,000 women), which was 37,000 more than at the end of October. The addition was accounted for entirely by the fact that there were more women at work in industry.

The Ministry's analysis of the civil employment figures shows that during November the number at work in the basic industries declined by 24,000 to 3,949,000. The decline, part of which can be said to be seasonal, occurred in transport and agriculture. The figure for coal mining, 699,000, was the same as a month earlier, though it was 5000 below the figure given for a year earlier. In the manufacturing industries, in November, the total manpower increased by 27,000 to 9,401,000. In this group the biggest increase, 10,000, occurred in " engineering, metal goods and precision instruments," under which classification an employment figure of 2,829,000 was returned at the end of November. The vehicle manufacturing industry added 2000, bringing its total at work to 1,258,000, and there was an increase of 4000 in metal manufacturing, in which 581,000 people were employed in November. In other industries and services the principal employment changes in November were a drop of 9000 in building and contracting, making the total 1,473,000, and an increase—undoubtedly a seasonal one—of 51,000 to the number employed in the distributive trades.

About unemployment, the Ministry's report says that on December 12th the number of people registered as out of work was 215,650, compared with 225,913 on November 14th. The December 12th figure included 9743 who were temporarily stopped. The report adds that, in the week ended November 26th, about 34,000 operatives in manufacturing establishments making returns were on short time, losing eleven hours each on the average. On the other hand, there were 1,820,000 production workers who were reported to be working, on the average, eight hours' overtime.

Full Employment

In a statement which has been circulated with the annual report of Martins Bank, Ltd., the chairman, Mr. A. Harold Bibby, has included some comments on the subject of full employment. He points out that the number of vacancies in practically every industry has exceeded the number of those unemployed and those unemployable. The scarcity of manpower and materials, Mr. Bibby says, has led many to seek the full advantage of their bargaining power, either by manufacturers raising the price of their products because they are in short supply or by unions pressing for higher wages. When full employment reaches a point where the worker, be he managerial, clerical or manual, ceases to feel that efficiency and effort are essential, then the blessings of full employment vanish and retribution will soon follow.

Mr. Bibby then says that " automation " is being held up in some quarters as the forerunner of future unemployment. This, he comments, will be as false an alarm for the future as the early fear of mechanisation proved itself to be in the past. Taking industry as a whole, the statement goes on, the biggest advances in employment have proved to be in those industries where mechanisation has been fully and enthusiastically applied. Not only have the people employed in those industries benefited themselves, but by expanding their production countless amenities have been made available to the country as a whole. Those industries, employers and employees alike, Mr. Bibby considers, which wholeheartedly adopt advanced mechanisation, will expand and flourish, while those which through lack of capital or enterprise or through fear refuse in this country to accept the international benefits of science will decline and shrink, outpaced and outclassed by their more venturesome competitors abroad. The real threat to full employment, Mr. Bibby suggests, is rejection rather than acceptance of increasing mechanisation. But, he adds, if this view is generally accepted, the country needs much greater facilities for higher technological education in all branches of industry.

Inevitably, the statement continues, in industries where automation is accepted and applied, the question will arise of how the benefits are to be shared. First of all, the cost of installation and provision for its systematic replacement by still newer plant will have to be met and the organising ability of those responsible for working out its physical introduction rewarded. When these claims for consideration have been met, Mr. Bibby remarks, there will remain a substantial portion to be divided on a fair basis between lower prices to the consumer, increased prosperity for the industry and material benefits to the workers who operate it.

Report on Coal

At the end of last week the chairman of the National Coal Board, Sir Hubert Houldsworth, issued a statement surveying the Board's performance during 1955. The saleable output of deep-mined coal was 210,190,000 tons, which was 3,370,000 tons less than in 1954. The average manpower throughout last year was 704,000 (compared with 707,000 in 1954), and the overall output per manshift was 24·5 cwt against 24·62 cwt in 1954. Last year's opencast coal production was 11,370,000 tons, or 1,310,000 tons more than in the preceding year, so that the total saleable output of coal in 1955 was 221,560,000 tons. Commenting on the deep-mined figures, Sir Hubert said that output a manshift at the coal face last year was the highest in the industry's history. Overall productivity fell slightly from the record level of 1954, though some of that fall could certainly be attributed to additional shifts, development and special work, and the decline in manpower at the face.

Sir Hubert went on to say that, last year, manpower declined by 5200, mainly in three divisions, North Eastern, West Midlands and South Western. Other divisions, apart from the North Western, gained men numbering 1700. The North Eastern, West Midlands and parts of the South Western divisions remained the principal manpower deficiency areas. There were vacancies, Sir Hubert said, for about 13,000 men, and even after those gaps had been filled the demand for manpower would continue in the expanding colliery areas. Total recruitment, at 61,200, was slightly better than in 1954. Over 2400 more men were recruited collectively last year in the Scottish, Durham, Northern and South Eastern divisions, but this gain had been offset by lower recruitment in the North Eastern, West Midlands, South Western and East Midlands divisions. The wastage of colliery manpower last year was 66,800, or 5800 more than in 1954. In the highly industrialised areas, Sir Hubert explained, there were fewer recruits and more wastage " in spite of all the efforts made by the Board and the Ministry of Labour to improve the position, by national publicity and other methods." Sir Hubert added that the Board's development programme was making demands on manpower but, naturally, produced no immediate returns in output. The number of men employed in 1955 on capital development and special work was 38,500, most of them experienced face workers.

The loss of coal through disputes last year was 2,688,000 tons, or 1,044,000 tons more than in 1947, hitherto the worst year since nationalisation. Nearly 1,000,000 tons last year were lost in one strike in Yorkshire about fillers' wage rates, and much more than half the total loss occurred in that coalfield. The Northern and Durham divisions between them lost only 16,000 tons during the year but they were the only divisions to lose less coal through disputes than in 1954, although the losses in some other divisions were not large. The conciliation machinery, Sir Hubert affirmed, where it was used properly, was obviously capable of remedying grievances with little unrest.

Manufacturing Industry's Stocks

In last week's number of the *Board of Trade Journal* there was included some information about the stocks of materials and the value of the work in progress in this country's manufacturing industries. The Board of Trade explains that for the last two years it has obtained figures of the value of stocks and work in progress at the end of each quarter from a number of large manufacturing companies. This information has proved useful in indicating short period changes in the level of stocks and work in progress. About 170 large manufacturing companies are asked each quarter to provide an estimate of their stock figures at the beginning and end of the quarter, distinguishing as far as possible materials and fuel, work in progress and finished goods.

It is estimated that the reporting companies account for about one-third of the total value of stocks and work in progress held by manufacturing industry, which total, at the end of 1954, was about £3,600 million. For the years 1953 and 1954 the changes in stocks of manufacturing industry as a whole indicated by the inquiry were in fair agreement with the results obtained from the censuses of production. But the Board of Trade acknowledges that a weakness of the inquiry is that information is obtained only from larger companies, as this may introduce an element of bias in the results.

The Board of Trade says, however, that both the quarterly inquiry and the census of production reveal little change in the total value of manufacturing industry's stocks and work in progress between the beginning and end of the calendar year 1953. A slight fall in the value of stocks of materials and fuels was matched by a slight increase in the value of work in progress, while the value of stocks of finished goods was unchanged. The quarterly inquiry showed a steady building up of stocks during 1954 and an increase of 7 per cent over the year. Index numbers obtained from the quarterly inquiry of changes in the total value of stocks and work in progress during 1955, taking December, 1954, as 100, are : March, 106 ; June, 108, and September, 112. The Board of Trade says that the increase in the value of stocks of materials and fuel and work in progress during the first nine months of 1955 was slightly greater than that in the value of stocks of finished goods.

Anglo-Canadian Trade

This week discussions have been held in Toronto between members of the Dollar Exports Council and members of the Dollar Sterling Trade Council. The object of this latter body is to increase the flow of Anglo-Canadian trade and already it has done a great deal to emphasise the advantages to the Canadian economy of larger imports from Great Britain. At the same time the Dollar Exports Council is intensifying its efforts in this country to increase exports to Canada. At this week's talks, consideration has been given to the practical measures that can be taken by industry in both countries to raise the level of United Kingdom exports to Canada. There has also been a study of reports on the missions from the Canadian pulp and paper, metal mining, and oil and fisheries industries which have visited the United Kingdom during the last eighteen months at the invitation of the Dollar Exports Council.

International Atomic Exposition at Cleveland

BY OUR AMERICAN EDITOR

No. I

The first International Atomic Exposition was held at the Public Auditorium in Cleveland, Ohio, from December 10th to December 16th in conjunction with a Nuclear Engineering and Science Congress. The exhibition was organised under the sponsorship of the American Institute of Chemical Engineers and was attended by some 20,000 visitors. It presented a comprehensive picture of the current state of development in the application of atomic energy in American industry, and this article reviews certain exhibits of particular interest.

WHILE the Geneva atomic energy conference, held last summer, constituted a truly important event of an international character, the atomic exhibition and congress which were recently held at Cleveland, Ohio, have had similar significance with regard to the latest American developments in the field of nuclear energy and its applications. Beyond doubt, the meeting was the most elaborate unclassified atomic convention held in the United States to date. Although the papers presented included five from Canada, two from the U.K., and one from South Africa, the conference represented an almost exclusively American point of view. Each of the papers presented was sponsored by one of the twenty-six participating scientific and engineering institutions. The Atomic Industrial Forum, which has long been interested in the legal and insurance problems associated with the field of atomic industry, sponsored a special meeting on the subject. The "International Atomic Exposition," which was held in conjunction with the Nuclear Engineering and Science Congress, included nearly 200 exhibitors from the U.S. and abroad and was sponsored by the American Institute of Chemical Engineers. The displays offered covered such items as design engineering services, package power reactors, medical and research reactors, construction and fabrication techniques, controls systems, reactor materials, instrumentation, particle accelerators, measuring instruments, laboratory equipment, fuel elements and other reactor components.

Combustion Engineering, Incorporated

The growing activities of Combustion Engineering, Incorporated, New York, in the nuclear reactor field since 1946 are representative of the current trend among American manufacturers of steam generating equipment to play an important part in the generation of power by atomic means. Within the past year the firm became the third contractor to the U.S. Atomic Energy Commission to enter the Naval Reactor Development Programme and the first to undertake the design and construction of a naval nuclear reactor system with its own facilities. The exhibit included a model of the 60MW Westinghouse nuclear power plant to be situated at Shippingport, Pennsylvania, and to be operated by the Duquesne Light Company. A pressurised water reactor system will be used to produce saturated steam at 600 lb per square inch gauge pressure. The reactor core will be contained in a vessel developed, designed and now being manufactured by Combustion Engineering. The illustration reproduced in Fig. 1 indicates to some degree the size of this vessel. It will be made of stainless-clad carbon steel measuring about 8½in in thickness. The vessel itself will be approximately 9ft inside diameter, will have an overall height of about 32ft and will weigh in excess of 200 tons. It is designed for 2500 lb per square inch gauge pressure and will be one of the largest diameter vessels ever built for such a pressure. The head of this vessel must be removable in order to reload the reactor when necessary. When the unit is operating an upward force of about 25,000,000 lb is exerted against the removable head. The specially designed studs used to secure it weigh nearly 600 lb each.

The reactor to be used has been designed to have a minimum full-power rating of 790×10^6 B.Th.U. per hour. The plant consists of a single reactor heat source with four main coolant loops. Three of these loops are required for producing the 60MW minimum design power.

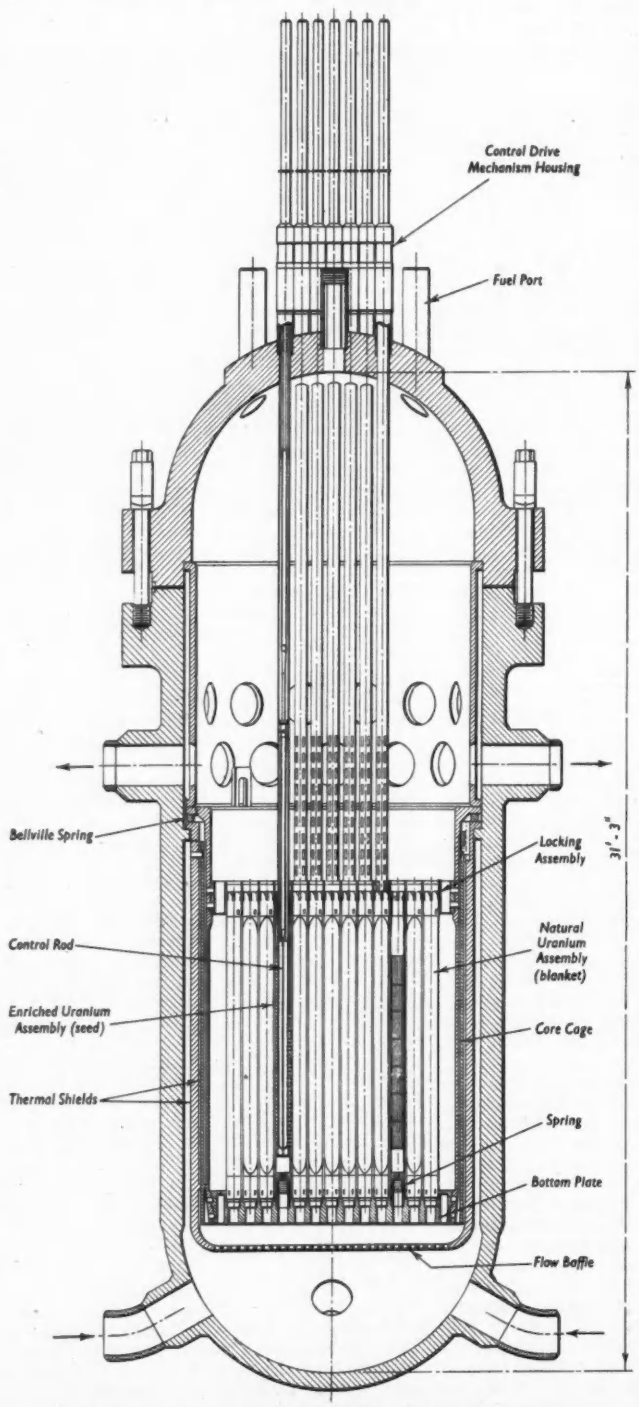


Fig. 1—Reactor core vessel for 60MW nuclear power station at Shippingport, Pennsylvania

Each loop consists of a single-stage centrifugal canned motor pump, a heat exchanger section of a steam generator, 16in gate isolation valves, and the necessary 18in outside diameter interconnecting piping. High-purity light water serves as both the coolant and the moderator. This water is under a pressure of 2000 lb per square inch. The flow through the nuclear core is 45,000 gallons per minute for three loops. At full power the inlet water temperature to the reactor is 508 deg. Fah. and the outlet temperature is 524 deg. Fah. The water velocity in the 18in pipes is approximately 30ft per second, with a velocity of between 10ft and 20ft per second in various parts of the nuclear core. The total pressure drop around the main coolant loop is 105 lb per square inch, and this drop is divided about equally between the core, steam generators and piping.

The coolant enters the bottom of the reactor vessel, where 90 per cent of the water flows upward between the fuel plates and rods, with the remainder by-passing the core in order to cool the walls of the reactor vessel and the thermal shield. After having absorbed heat as it goes through the core, the water leaves the top of the reactor vessel through the outlet nozzles. It then passes through two 16in isolation valves in series and goes through the heat exchanger section of the steam generator. The water then flows through the canned motor pump and back through the inlet isolation valves to the bottom of the reactor vessel, completing the cycle. Isolation valves are situated immediately adjacent to the reactor inlet and outlet nozzles of each of the four loops. These valves permit isolation of any loop of the reactor plant, to provide maximum protection to the reactor and so that maintenance can be performed while the remainder of the loops are in operation. The main coolant flows through the inside of many hundreds of small stainless steel tubes in the heat exchanger section of the steam generators. These heat exchanger tubes are surrounded by the water of the secondary system, which is heated by the primary coolant in the tubes. Wet steam is formed, which passes upward through the risers and enters the steam separator portion of the steam generator. Here the moisture is removed and returned to the heat exchanger section through the downcomers. The dry and saturated steam at 600 lb per square inch absolute, at full power, leaves the top of the steam separator and goes to the steam turbine.

Babcock and Wilcox Company

The Babcock and Wilcox Company, of New York, announced at the exhibition that it had

received from the U.S. Atomic Energy Commission the first American lump-sum contract to build reactor fuel elements in a privately owned facility. The contract was let on competitive bids and calls for at least 325 fuel element assemblies to replenish the core of the Materials Testing Reactor at Arco, Idaho, which is operated by the Phillips Petroleum Company for the A.E.C. A prototype fuel element of the kind to be built under the contract has already been manufactured and was exhibited at the firm's booth. The unit was built at the company's temporary works facilities at Lynchburg, Virginia. A new fuel element fabrication plant now under construction at Lynchburg is expected to begin full-scale operations this spring and will be the first such major facility in American private industry. The firm also had on display at Cleveland models of the fuel elements which will be used in the reactor in the 236MW atomic-electric power station which the Consolidated Edison Company will build near Indian Point, New York. Babcock and Wilcox has a contract to design and build the nuclear portion of this plant which will supply electric power to the New York City area. This is the first such American plant to be conceived and financed solely on a private enterprise basis and is also the largest yet proposed.

The company's exhibit also stressed the interesting work which has been conducted by a group of industrial concerns under the direction of Babcock and Wilcox in studying liquid metal fuel reactor systems and their application to a nuclear power plant. Briefly, the proposed power plant is composed of two primary loops : one, the fuel stream, containing a solution of uranium in bismuth, and the other, the blanket stream containing thorium-bismuthide dispersed in bismuth. Furthermore, there is a secondary system containing liquid lead-bismuth eutectic which transports the heat to a steam generator and a steam turbo-generator plant. The reactor, heat exchangers, pumps, valves and piping are the major components of the primary loop.

In the opinion of the company, the use of nuclear fuel in the liquid state, rather than in the presently more conventional form of solid fuel elements, is desirable for the following reasons : (1) radiation damage to liquid fuels is negligible compared to that to solid fuels. In solid fuels this damage often determines the permissible amount of burn-up, while in liquid fuels there is no restriction on burn-up due to radiation damage ; (2) liquid fuel may be loaded and unloaded from the reactor through pipelines and, therefore, the use of complicated remotely operated mechanical devices is not required ; (3) the preparation of liquid fuels is easier and cheaper than the fabrication of solid fuel elements. The cladding of solid fuels to provide structural support for the fuel and to prevent its corrosion or chemical reaction with the coolant is often a difficult and costly operation ; (4) the structural materials required to support solid fuel elements, which include the cladding, grid plates, &c., absorb neutrons that otherwise would contribute to the fission process. Additional amounts of fissionable material are thus required to compensate for these poisons. The use of liquid fuels requires no support structures other than containers ; (5) liquid fuels may be purged of fission product poisons during reactor operation. New fuel may also be added to replace that being burned up, while solid fuel elements must be removed from the reactor and reprocessed. By keeping the poison level low in liquid fuels, the neutron economy is improved and a better breeding ratio can be achieved ; (6) the temperatures attainable in liquid fuels are usually higher than those permissible with solid fuel elements ; (7) the temperature drop between the solid fuel and the coolant is eliminated when liquid fuels are used, thus permitting higher primary fluid exit temperatures; (8) in the case of solid fuel elements, neutron flux variations in the reactor produce local hot spots within the core, thus limiting the average heat flux which in turn limits the coolant exit temperature.

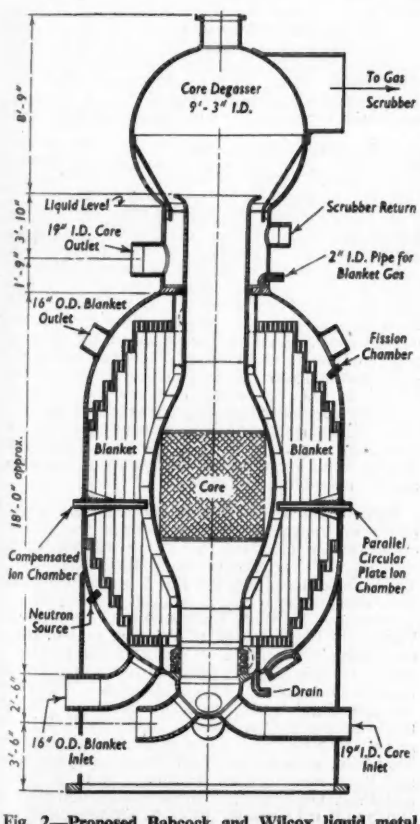


Fig. 2—Proposed Babcock and Wilcox liquid metal fuel reactor with graphite moderator and steel core vessel

Because a solution of uranium in bismuth has a low neutron absorption and fission products can be continuously removed, the proposed liquid metal fuel reactor can be used as a breeder.

One concept of the company's liquid metal fuel reactor which is illustrated in Fig. 2, involves a reactor core consisting of a graphite moderator containing passages through which the liquid metal fuel flows. This core is surrounded by a thin steel vessel and an annular region or breeder blanket which consists of graphite containing flow passages for the blanket fluid. A degassing vessel is situated on the top of the reactor, through which the liquid fuel fountains to effect the removal of volatile fission products.

Another proposed version of the Babcock and Wilcox liquid metal fuel reactor is illustrated in Fig. 3. In this design the entire primary circuit is contained within one vessel, further reducing the fuel inventory by containing the fuel in graphite tubes within the core. Heat generated due to fission is transferred to the blanket fluid which flows through an annulus around the fuel tubes and then flows to the heat exchangers. All the fuel tubes are connected to a header and a small flow is maintained through each tube to facilitate heat transfer to the blanket fluid and to enable the fuel to be processed to remove fission products.

The principal restriction to the construction of the "integral" reactor, shown in Fig. 3, is the limited mechanical strength and "fabricability" of graphite and the difficulty of graphite-to-steel jointing.

The particular design shown in Fig. 2 was developed by the firm for a power plant of

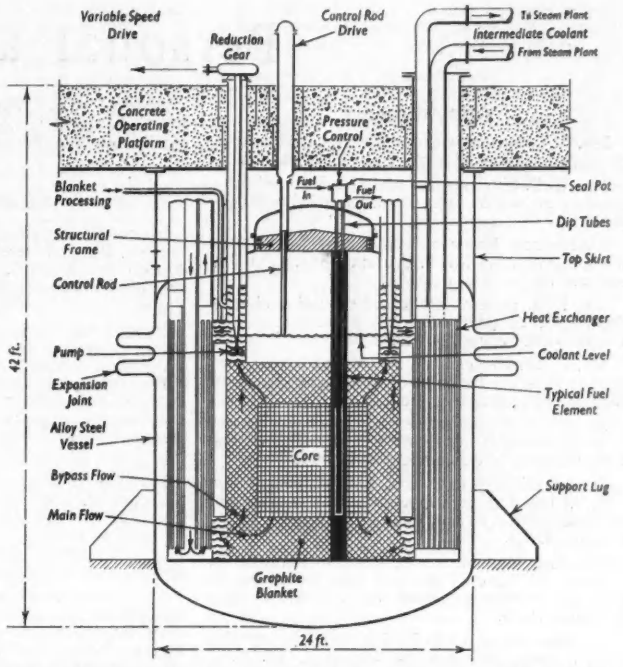


Fig. 3—Proposed Babcock and Wilcox liquid metal fuel reactor employing internal cooling with entire primary circuit contained in reactor vessel

550MW reactor heat. The fuel solution, at a flow rate of 36,000 gallons per minute, enters the reactor at the bottom at 752 deg. Fah. and leaves at the top at 1022 deg. Fah. and transfers 500MW of heat. The breeder blanket flow rate is 3600 gallons per minute ; the temperature levels are the same as for the U-Bi solution and the fluid transfers 50MW of heat. Since the blanket fluid is a suspension, precautions must be taken in order that the fluid remains homogeneous. Calculations indicate that a velocity of 0·01ft per second is sufficient to prevent settling with upflow.

The reactor consists of three distinct vessels : (1) an inner thin-walled core vessel which supports the graphite moderator and contains the fuel solution ; (2) an outer reactor container, which encompasses both the core and the breeder blanket ; and (3) a degassing vessel supported on a shelf atop the reactor container. The reactor core consists of a mass of graphite 5ft in diameter and 5ft in height, drilled with 511 2in diameter holes on a 2½in triangular pitch. The graphite must be impervious to prevent the absorption of bismuth containing uranium and fission products. Such materials lodged in the pores of the graphite might crack or deform it.

The core vessel, which is $\frac{1}{16}$in thick, supports the graphite on a circular ledge at the bottom when the core does not contain bismuth, and, by means of a similar ledge at the top, prevents the graphite from floating (since graphite is approximately one-sixth as dense as bismuth) when the vessel is filled with bismuth. The 39in I.D. inlet and exit manifolds and the transition sections into and out of the core are formed by extensions of the core vessel. The breeder blanket consists of a 3ft thick region situated circumferentially around the core, and is enclosed at its outer diameter by the 1¼in thick reactor vessel. The blanket contains approximately 730 hollow extruded rods of impervious pile-grade graphite. The ends of the rods are set into upper and lower steel grids, which in turn are welded to the reactor vessel and act as guides and supports. A 6in annulus adjacent to the core vessel on the blanket side contains no graphite. This zone of immoderation is provided to enhance the breeding capabilities of the blanket. The operating pressures in both the core and blanket portions of the reactor are low because the vapour pressure of bismuth is negligible (0·0166 microns at the average reactor temperature of 887 deg. Fah.). The pressure is highest at the bottom and amounts to about 125 lb per square inch in the core and 100 lb per square inch in the blanket. These values are due to the heights of liquid contained in the respective portions of the reactor and to the pressure drops in each.

Personal and Business

Appointments

MR. A. L. SUTHERLAND and Mr. H. C. White have been appointed directors of Philips Electrical, Ltd.

MR. W. P. HOWARD has been appointed publicity manager of Ferodo Ltd., Chapel-en-le-Frith, Stockport.

RUSTON AND HORNSBY, Ltd., Lincoln, announces the appointment of Mr. P. F. Dilnot, M.I.Mar.E., as assistant marine sales manager.

MR. K. J. DOWELL has joined the technical sales department of Smiths Aircraft Instruments, Ltd., Cricklewood, London, N.W.2.

MR. G. W. HESLETT and Mr. Marcel Zublin have been appointed to the board of Sulzer Bros (London), Ltd., 31, Bedford Square, London, W.C.1.

MR. GILBERT HUNT has been appointed general manager of High Duty Alloys, Ltd., Slough. He has been a director of the company since 1951.

FINA PETROLEUM PRODUCTS, Ltd., states that Mr. J. R. V. Cooper has been appointed manager of the fuel oil department at its head office at 25, Victoria Street, London, S.W.1.

MR. R. F. WALTERS has been appointed managing director of Harvey Frost and Co., Ltd., and its associated company, Ernest Lake, Ltd., Bishop's Stortford, Herts.

KENNEDY AND DONKIN, 12, Caxton Street, London, S.W.1, state that Mr. H. Headland, M.I.C.E., M.I.E.E., who has been a senior member of their staff for some years, has been appointed a consultant to their firm.

THE BRUSH GROUP, Ltd., states that Mr. B. R. Cant has been appointed general works manager of The National Gas and Oil Engine Company, Ltd. Mr. S. Cooper is to succeed Mr. Cant as works manager of J. and H. McLaren, Ltd., Leeds.

THE MORGAN CRUCIBLE COMPANY, Ltd., announces the appointment of Mr. D. Scott as manager of the branch at Carver Street, Birmingham. He is to succeed Mr. G. E. Richards, who will retire at the end of March, after forty years in the company's service.

MR. C. CLENCH, Mr. C. Hayes, Mr. A. R. W. Murray, Mr. F. Rowarth, Mr. P. A. Rippon, Mr. J. K. Simpson, Mr. H. Unsworth and Mr. D. J. Watkins have been appointed executive directors of Automotive Products Company, Ltd., and its associated companies.

RHODES, BRYDON AND YOUATT, Ltd., Waterloo Engineering Works, Stockport, announces the appointment of Mr. R. A. H. Smith as technical representative for the S.W. England and South Wales area. Mr. Smith's address is Farmborough, near Bath (telephone, Timsbury 425).

THE SUPERHEATER COMPANY, Ltd., states that Mr. H. Melhuish has been appointed assistant managing director and head of the power plant division. Mr. L. C. Southcott, who is a director of the company, continues as chief engineer, and, in addition, has been appointed personal assistant to the managing director, Mr. Eric A. Robinson.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough, announces the appointment of Mr. B. L. Goodlet, M.I.C.E., M.I.Mech.E., M.I.E.E., as chief engineer and director. Mr. Goodlet, who will take up this new appointment on April 1st, is at present deputy chief engineer at the Atomic Energy Research Establishment, Harwell, with responsibility for engineering research and development.

EDGAR ALLEN AND CO., Ltd., Sheffield, states that Mr. E. D. Eastburn has been appointed technical representative for engineers' tools and tool steels in Lancashire, Cheshire, Westmorland and Cumberland. Mr. L. J. Etheridge has been appointed to a similar position in the Midlands and Lincolnshire. Mr. J. L. Lee is to succeed Mr. A. P. T. Taylor-Gill as special representative of Edgar Allen and Co., Ltd., in Australia and the Far East. Mr. Lee is attached to Noyes (Australia) Proprietary, Ltd.

Business Announcements

F. PERKINS (CANADA), Ltd., has moved into a new building at Wingold Avenue, Toronto.

MR. J. ARTHUR REAVELL, M.I.Mech.E., chairman of the Kestner group of companies, is on a visit to South Africa.

BAIRD AND TATLOCK (LONDON), Ltd., states that its chairman, Mr. J. E. C. Bailey, is leaving for a visit to Africa on January 27th.

SAUNDERS ROE, Ltd., has announced the retirement of Mr. H. Knowler, who has been technical director since 1952, and chief designer since 1928.

NEWTON SALES COMPANY, Ltd., 517-523, Fulham Road, London, S.W.6, states that its telephone number has been changed to Fulham 4228.

Contracts

INTERNATIONAL AERADIO, Ltd., 40, Park Street, London, W.1, has received an order from Vickers-Armstrongs (Aircraft), Ltd., for the supply of an engineered system for the air traffic control tower at Wisley Airport, near Ripley, Surrey.

VICKERS-ARMSTRONGS, Ltd., has received from British European Airways an order for twenty "Vanguard" V.901 air liners, with Rolls-Royce "Tyne" propeller turbine engines, for delivery in 1959/60. Orders for "Viscount" aircraft now total 274, including sixty-five for B.E.A., to whom twenty-six have been delivered.

BIRLEC, Ltd., Birmingham, will shortly begin the construction of a second arc melting furnace at the Stocksbridge, Sheffield, works of Samuel Fox and Co., Ltd. The new furnace, which will be larger than the existing furnace, is to have a shell diameter of 20ft, a transformer capacity of 20,000kVA, and will be provided with on-load tap-change gear.

BAIRD AND TATLOCK (LONDON), Ltd., 14-17, St. Cross Street, London, E.C.1, has recently received contracts for laboratory installations from the Northern Region Production Development Board, Kaduna, Nigeria (value £2400); the Veterinary Laboratories, Astrida, Belgian Congo (value £5000); the laboratories of Thorium, Ltd., Ilford, Essex (value £13,000), and the laboratories of the Castle Donington power station, Leicestershire (value £3000).

Miscellanea

CIVIL ENGINEERING WORKS IN SPAIN.—An exhibition of photographs of roads, bridges and hydro-electric works in Spain will be open at the Building Centre, Store Street, Tottenham Court Road, London, W.C.1, until January 28th. It has been arranged by the Spanish Embassy.

SIR RICHARD REDMAYNE.—A memorial service for the late Sir Richard Redmayne, whose death was recorded in our issue of January 6th, is to be held at St. Margarets, Westminster, London, S.W.1, on Thursday next, January 26th, at 12.30 p.m. The arrangements for this service are being made by the Institution of Civil Engineers, the Institution of Mining and Metallurgy, and the Institution of Professional Civil Servants.

NEW BURNING POSITIONS FOR "OSRAM" SODIUM LAMPS.—We learn from the General Electric Company, Ltd., that, as a result of manufacturing improvements and field experience, a wider range of burning positions is now possible with "Osram" sodium lamps. Previously the company recommended that these lamps should not be used with the cap set lower than any other part of the lamp, to avoid deterioration of the cathode and pinch caused by attack from molten sodium. Now a downward inclination of 5 deg. below the horizontal is permissible.

MR. A. E. INGHAM.—We have learned with regret of the death of Mr. Arthur Edward Ingham, which occurred suddenly on January 9th. Mr. Ingham, who was seventy-four, was until recently joint managing director of George Richards and Co., Ltd., Broadheath, Manchester, and was also a director of Tilghman's, Ltd. He spent the whole of his working life with George Richards and Co., Ltd., having begun his apprenticeship in 1896. After serving in the works and drawing-office, Mr. Ingham became general manager, and, in 1929, was appointed a director.

TRADE RELATIONS COMMITTEE.—The first meeting of the trade relations committee of the Council of Association between the United Kingdom Government and the High Authority of the European Coal and Steel Community was held in London on January 9th. The committee had an exchange of views on conditions of trade in coal and steel between the United Kingdom and the European Coal and Steel Community and fixed its further programme of work. The next session of the committee will be held in Luxembourg on April 10th, or earlier if necessary.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—"The Modern Manufacture of Steel Plate for Shipbuilding" was the title of the paper presented by T. F. Pearson, M.Sc., before the North East Coast Institution of Engineers and Shipbuilders on January 13th. The paper discusses the significance of shipbuilding in relation to steel-making and goes on to deal with the acid and basic processes of manufacture, refining in the open-hearth furnace, the teeming and the ingot stage, and the treatment of the ingot. The section on plate rolling includes descriptions of a two-high roughing and finishing mill, a three-high mill, a four-high reversing mill, and continuous mills, followed by notes upon rolling mill drives, characteristics of the rolling and finishing operations and mechanical testing. The chemical, physical and mechanical properties of ship plate are surveyed and there are remarks upon the growth of welding in shipbuilding, the question of brittle fracture and the development of improved steels.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—On January 10th L. T. Morton, B.Sc. (Eng.), read a paper entitled "Cargo Handling Appliances" before the Institution of Engineers and Shipbuilders in Scotland. In the paper cargo-handling equipment is considered from the point of view of the shipowner wishing to reduce time in port. Special consideration is given to the working of the cargo in the wings of the hold, where a direct lift is not possible, and the possibility of adopting a layout for accommodation that would facilitate cargo handling is mentioned. The operation of ships' winches and the selection of driving power is surveyed.

RADIO-FREQUENCY CABLE WITH STABLE VELOCITY OF PROPAGATION.—A new r.f. cable has been introduced by The Telegraph Construction and Maintenance Company, Ltd., Greenwich, S.E.10. It is designed to inhibit the variations in phase-constant that may occur during the handling of flexible solid-dielectric r.f. cables of normal construction. This defect is caused by the fact that tightening or loosening of the braided outer conductor alters the proportion of air to solid dielectric in the cable insulation and, thereby, changes the velocity of propagation. The new cable is a modification of the "Telcon" UR67 cable and is designated PT93MW; it shows a four-fold improvement in stability of propagation velocity.

MOND NICKEL FELLOWSHIPS.—The Mond Nickel Fellowships Committee invites applications for five fellowships, of an approximate value of £900 to £1200 each, for 1956. Fellowships will be awarded to selected candidates of British nationality with degree or equivalent qualifications to enable them to obtain wider experience and additional training in industrial establishments, at home or abroad, to make them more suitable for future employment in senior technical and administrative positions in the British metallurgical industries. Each fellowship will cover one full working year. Applicants will be required to state details of the programme they wish to carry out. Particulars and forms of application are available from the Mond Nickel Fellowships Committee, 4, Grosvenor Gardens, London, S.W.1. Completed application forms must be submitted by June 1st next.

ZINC DEVELOPMENT ASSOCIATION.—New offices of the Zinc Development Association were opened at 34, Berkeley Square, London, W.1, on January 10th, by the President of the Board of Trade, Mr. Peter Thorneycroft. The ground floor contains the library and a small waiting room, in which there are exhibits and charts showing the main properties of zinc. A staircase from the waiting room leads to the basement and to an exhibition room which will be used for special exhibitions which will be changed from time to time. On the first floor there is the council room, which has been fitted up for showing films, and the director's office. These two rooms are connected by folding doors which can be opened for receptions. On the second floor are the offices of the chief technical officer, the secretary and the technical officers concerned with galvanising. On the third floor there are offices for the technical officers dealing with die casting for the production engineers and for the main typing pool.

BRITISH ELECTRICAL POWER CONVENTION.—Electricity in transport will provide the theme of the eighth British Electrical Power Convention, which will open at Torquay on Wednesday, May 23rd. The main technical sessions will be on Friday, May 25th, when the following papers will be delivered:—"Electricity in Rail Transportation," by S. B. Warder; "Electrification of Railways in the Commonwealth," by E. L. E. Wheatcroft and H. H. C. Barton; "The Electric Locomotive and the Diesel Electric Locomotive," by C. M. Cock; "Electric Multiple Train Units," by F. A. Manley; "Electricity Supply and the Railway Load," by F. J. Lane and W. B. Noddings. Three papers will be given on May 26th, as follows:—"Overhead Lines for Rail and Road Electrification Schemes," by C. B. Allen and C. P. Goodman; "Substation Equipment for Rail and Road Systems," by G. S. Canson and F. G. Stevens; and "Electric Signalling Systems for Rail and Road Transport," by D. C. Shipp.

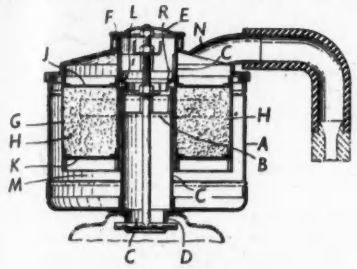
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

740,100. February 12, 1954.—AN IMPROVED AIR FILTER, Tecalemit, Ltd., Great West Road, Brentford, Middlesex.

The invention concerns an oil bath filter for internal combustion engines. Referring to the drawing, the air filter comprises a casing *A* in which there is at least one air inlet orifice *B* in the form of an elongated opening, extended towards the interior of the casing by a tube forming a silent suction device. An axial extension *C* of a tube *D* for filling the crankcase with oil passes through the casing. The extension opens out above the filter and is closed by a cap *E* provided with a gasket *F*. The bottom of the casing



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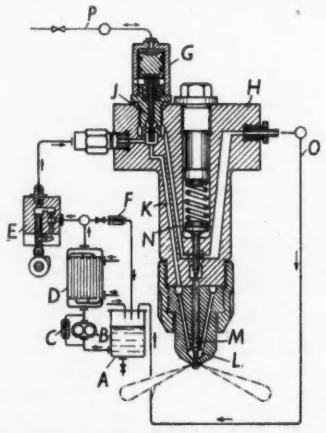
contains a certain quantity of oil for washing the air. An inner casing *G* contains a filtering material *H* in the annular space between it and the extension and is fixed to the cover or upper part of the filter which closes the casing. Spaced upper and lower perforated plates *J* and *K* of metal gauze fixed to the tube extension *C* and the casing *G* also enclose the material *H*. The extension of the oil-filling tube is formed in two parts, one actually connected to the flange *D* and within the other. Between these parts there is a small annular opening *L* which puts the interior of the oil-filling tube into communication with a zone of the filter *M* subjected to the vacuum caused by the induction system of the engine which permits suction into it of the oil vapour in the crank-case and the valve push-rod casing. After having passed through the filtering material the air is conducted to an outlet formed in the cover and connected by a short tube *N* to the carburettor. The crank-case is filled with oil through the tube *C*, a deflector *R* preventing the oil entering through the opening *L*. The specification also shows the manner in which the filter is mounted on an internal combustion engine having valves actuated by push-rods. —*November* 9, 1955.

740,217. March 1, 1954.—FUEL INJECTION SYSTEMS, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

The invention relates to fuel injection systems for internal combustion engines, such as diesel engines, employing preheated fuel. As shown in the drawing, fuel is drawn from a tank *A* by a low pressure pump *B* provided with a relief valve *C* and is delivered to a preheater *D*. Heated fuel from the preheater passes



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into the fuel injection pump *E*, any surplus fuel being returned to the tank through a relief valve *F*. From the injection pump the fuel is delivered to a valve *G* mounted in the injector body *H*. Depending upon the position of the movable member *J* of the valve *G*, the fuel is delivered either through a passage *K* into the nozzle chamber *L* of the injector, which chamber contains the tip of the needle *M*, or through a heating passage *N* leading to a pipe *O* which returns to the tank. Instead of the heating passage there could be a passage leading from the valve *G* to the outlet pipe *O* by the shortest route. Alternative designs of the valve *G* are also described which can be hand-operated or automatically actuated by compressed air admitted through a pipe *P*. During the warming-up period, as soon as the fuel has been preheated to reduce its viscosity sufficiently, the injection pump delivers it to the injector, the movable member *J* of the valve *G* being in its lower position in which it blocks off the entrance to the passage *K* and opens the entrance to the passage *N*. The hot fuel, therefore, flows through the heating passage *N* and so warms up the injector. The size, shape and disposition of the heating passage can be adapted to suit requirements. For example, it may comprise several parallel passages all leading from the valve *G* and passing through different parts of the injector body until they meet again at the entrance to the return pipe *O*. As soon as the various parts have been warmed up sufficiently, the system can be brought into a condition suitable for starting the engine, by raising the movable member *J* of the valve *G* so that the entrance to the heating passage *N* is blocked and the passage *K* leading to the nozzle chamber is opened. An advantage of this system in which the injector is heated is that the risk of the needle *M* sticking owing to the high viscosity of the fuel is substantially eliminated and satisfactory injection is assured even when the engine is being started. A further advantage is that the volume of the heating passage can be made as large as is desired without increasing the volume of fuel which is under high pressure during injection.—*November* 9, 1955.

GAS TURBINES

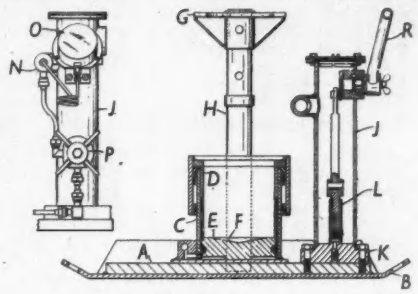
740,062. April 14, 1954.—REDUCING HARMFUL EFFECTS OF COMBUSTION PRODUCTS, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

According to the invention, a method of reducing harmful effects of combustion products in a gas turbine plant comprises adding different substances at at least two different points in the gas path through the plant. It is recommended to introduce at a hot point in the plant a substance which is effective against corrosion and which is non-sintering, and to introduce at a cooler point a substance which will decompose and prevent the formation of further sulphates. At a hot point magnesium oxide can be added and at a cooler point an aluminium silicate, for example, kaolin or montmorillonite. In place of magnesium oxide, a compound which produces magnesium oxide under the conditions experienced, or even magnesium metal, could be used. The amount of the magnesium oxide added should be suited to the vanadium content of the fuel and should be as small as possible, since magnesium oxide could be converted into magnesium sulphate which would act as a further deposit-forming sulphate in addition to the other sulphates which may be present. The amount of aluminium silicate added should be suited to the alkali metal or alkaline earth metal content of the fuel, while taking into consideration also any excess of magnesium oxide that may be added. In the case of a gas turbine plant, a relatively small amount of magnesium oxide would be added in front of the air heater for the purpose of reducing the harmful effects of the vanadium content of the fuel, and a greater amount of kaolin would be added after the air heater and before the turbine in order to prevent the formation of sulphate deposits in this part of the plant. As an alternative to magnesium oxide, zirconium silicate could be used.—*November* 9, 1955.

MINING ENGINEERING

740,016. May 29, 1953.—HYDRAULIC PIT PROP TEST APPARATUS, Dowty Hydraulic Units, Ltd., (formerly Dowty Auto Units, Ltd.), Ashchurch, Tewkesbury. (*Inventor: Colin Michael Frye.*)

The object of the invention is to provide a test apparatus for hydraulic pit props which can be used underground within the limitations imposed by the height of the mine roof. As shown in the drawing, the apparatus comprises a generally rectangular base frame *A* with a skid plate *B* and carrying handles. The frame supports a hydraulic cylinder *C* with a bucket-shaped piston *D*, the base of which is formed as a platform *E* with a central depression *F* to locate and support the bottom of a prop to be tested. A column *H* is mounted at one side of the cylinder and it has at its upper end a vertically adjustable guide plate *G* with a semi-circular recess which locates and guides the lower tubular component of the prop coaxially with the piston and cylinder assembly. A hand pump assembly at one end of the base frame comprises a cylindrical oil reservoir *J* mounted on a base plate *K* to which a pump cylinder *L* is fixed within the reservoir. A relief valve *N* to prevent excessive pressure being developed in the test apparatus is provided, and a pressure gauge *O* is connected to the inlet of the valve. In operation, the prop to be tested is placed on the platform *E* and aligned by the guide plate *G*. The pump in the pit prop is then



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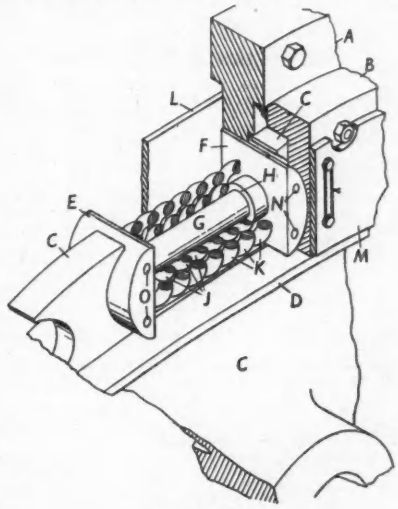
worked until the head of the prop rises to the roof of the mine. The release cock *P* of the test apparatus is then closed and the pump handle *R* of the apparatus is worked to raise the platform *G* supporting the base of the prop and thus build up a thrust load. When this thrust load reaches a value at or around the designed maximum loading for which the prop is designed, the relief valve in the pit prop will blow-off and the applied load at which this occurs is noted on the gauge *O*. If there is any discrepancy between the designed load and the load applied by the test apparatus, the pit prop relief valve may be adjusted on the spot and then re-tested until agreement is shown.—*November* 9, 1955.

POWER TRANSMISSION

741,744. March 18, 1953.—RESILIENT COUPLINGS, Thomas Hindmarch, Lindo Lodge, Stanley Avenue, Chesham, Buckinghamshire.

The invention relates in particular to resilient couplings for absorbing torsional vibrations in internal combustion engines. The object of the invention is to provide a coupling in which the resilient and/or damping means may be inserted or removed without dismantling the whole coupling, so providing a quick and cheap method of making the preliminary adjustments in setting up the system, and also allowing speedy replacement of any of the



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working elements which may become defective in service. In one form of construction as shown in the drawing, two discs *A* and *B*, which are fixed together, are held radially in true relation with the central disc *C* by flange *D* formed on the central disc. The two discs *A* and *B* form the input element of the coupling, while the central disc *C* forms the output element or vice versa. Slots are formed in these three discs, and in the slots are fitted the resilient elements which comprise two self-aligning or semi-cylindrical abutment members *E* and *F* having male and female cylindrical guiding means *G* and *H*. Between the abutment members are also fitted two concentric helical springs *J* and *K*. The resilient unit is prevented from axial movement by ring-like circular disc keep plates *L* and *M*. The fitting or removal of the resilient elements is arranged by bolting to the abutment members *E* and *F* the two parts of a clamp-like tool by means of tapped holes *N* and *O*, the removal of keep plates *L* and *M* being all that is necessary for this purpose. This construction provides similar torsional characteristics in either direction of rotation. In an alternative construction, hydraulic damping means may be provided in the guiding members *G* and *H*, and this damping means may have a constant characteristic or one which varies with the movement,

as, for instance, would be provided by a leakage slot of varying area. The invention may be applied to a gear incorporating a series torsional damper of the kind described and claimed in the prior specification No. 607,940, or a parallel torsional damper such as is described and claimed in the prior specification No. 594,904.—*December* 14, 1955.

Launches and Trial Trips

KHASIELLA, oil tanker ; built by the Netherlands Dock and Shipbuilding Company for N.V. Petroleum Maatschappij "La Corona" ; length overall 563ft 9in, length between perpendiculars 530ft, breadth moulded 69ft 3in, depth 39ft, deadweight 18,000 tons on 29ft 6in draught, speed 14½ knots ; thirty-three cargo oil tanks; one set of geared turbines, by N.V. Werkspoor, 8300 h.p.; two Babcock and Wilcox boilers. Launch, December 10th.

HELDIA, oil tanker ; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for Shell Tankers, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, load draught 29ft 9¼in, deadweight 18,150 tons, service speed 14½ knots ; thirty-three cargo oil tanks, one main cargo pump room, four 400 tons per hour turbo-vertical centrifugal cargo oil pumps, two stripping pumps, steam deck machinery ; two 550kW turbo-alternators, one 200kW diesel-driven alternator ; machinery supplied by the Wallsend Slipway Engineering Company, Ltd., one set of double reduction geared compound turbines, maximum power 8250 s.h.p. at 103 propeller r.p.m., service power 7500 s.h.p. at 100 propeller r.p.m., steam supplied at 500 lb per square inch and 800 deg. Fah. by two Babcock and Wilcox boilers. Trial, December 12th.

BAMENDA PALM, cargo liner ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for Unilever, Ltd.; length between perpendiculars 415ft, breadth moulded 58ft, depth to shelter deck 35ft ; five cargo holds and deep tank, one 75-ton, six 10-ton and ten 5-ton derricks, electric deck machinery, three 250kW diesel-driven generators, one 30kW diesel-driven generator ; Swan Hunter-Doxford oil engine, four cylinders 670mm diameter by 2320mm combined stroke, 4500 b.h.p., 118 r.p.m. Launch, December 14th.

Catalogues and Brochures

VACUUM OIL COMPANY, Ltd., Caxton House, Westminster, London, S.W.1.—Series of industrial technical bulletins entitled : No. 1, "S/V Ceremula" ; No. 2, "Industrial Petrolatums" ; No. 3, "Gargoyle Grease BRB No. 1 and Ball and Roller Bearing Lubrication" ; No. 4, "The Gargoyle Compounds and Enclosed Gear Lubrication" ; No. 5, "Oils for the Machine Shop" ; and No. 6, "The Gargoyle Dorcias and Open Gear Lubrication".

MECHANICAL HANDLING ENGINEERS' ASSOCIATION, 94–98, Petty France, London, S.W.1.—Exhibition brochure No. 3, illustrating the latest types of equipment available for the lifting and conveying of materials. The brochure is divided into two parts covering "Mechanical Handling in Countryside and Factory," and "In Docks and Harbours." An alphabetical list of members of the Association and their products is included.

INTERNATIONAL COMBUSTION, Ltd., 19, Woburn Place, London, W.C.1.—Illustrated catalogue giving details of the "Ty-Rock" full floating screen designed to effect the coarse and medium-sized screening of crushed rock, gravel, ores, coal and other materials.

COMMER CARS, Ltd., Luton, Beds.—Publications giving details of "Superpoise" ¾-ton and 1¼-ton models, 1½-ton forward control van, with price list and data book No. 37.

ALUMINIUM UNION, Ltd., The Adelphi, London, W.C.2.—Folder entitled "Magnesium for Cathodic Protection," dealing with the prevention of iron and steel corrosion.

KWIKFORM, Ltd., Waterloo Road, Birmingham, 25.—Illustrated catalogue dealing with the "Kwikform" Mk. II formwork system for concrete constructional purposes.

W. H. MARLEY AND CO., Ltd., New Southgate Works, 105, High Road, London, N.11.—Leaflet dealing with the standard range of "Marico" hydraulic power presses.

OWL ENGINEERING SUPPLIES, Ltd., 16, South Parade, Doncaster.—Illustrated brochure giving details of the design, construction and application of vibrator conveyors.

A. REYROLLE AND CO., Ltd., Hebburn, Co. Durham.—Pamphlet No. 935, giving details of "Easigo" metal-clad protected type electric plugs and sockets.

ALLEN WEST AND CO., Ltd., Brighton, 7.—Folder giving details of motor control equipment for all classes of mechanical lifting, transporting and sorting machinery.

FREDERICK W. EVANS, Ltd., Plastic Works, Long Acre, Birmingham, 7.—Leaflet illustrating a variety of handles and knobs showing shapes and sizes available.

RANSOMES AND RAPIER, Ltd., Waterside Works, Ipswich.—Publications Nos. 501 and 1/497, describing mobile cranes for handling loads up to 10 tons.

GEORGE KENT, Ltd., Luton, Beds.—Publication No. 377/1055, giving details, dimensions and mounting particulars of "Kent" gas-pressure controller.

PANTAK, Ltd., 72–76, Alpha Street, Slough, Bucks.—Illustrated leaflet describing 150kVp. mobile industrial X-ray unit, type "M.C.150."

Calendars and Diaries

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., Parnell House, Wilton Road, London, S.W.1.

BAILEY BROS. AND SWINFEN, Ltd., 46, St. Giles High Street, London, W.C.2.

THE PHOTOGRAPHIC SURVEY CORPORATION, Ltd., Canada.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Wed., Jan. 25th.—GLASGOW BRANCH : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Brushgear," A. Mair, 8 p.m.

BATTERSEA POLYTECHNIC

Tues., Jan. 24th.—Battersea Polytechnic, London, S.W.11, "Inspection of Ferrous Materials," J. F. Hinsley, 7 p.m.

BELFAST ASSOCIATION OF ENGINEERS

Wed., Jan. 25th.—College of Technology, Belfast, Film Night, "Fuel Oils," 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 25th.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Symposium on Electronic Methods of Pictorial Reproduction, "Facsimile Communication," H. F. Woodman and P. H. J. Taylor ; "Facsimile Transmission of Weather Charts," J. A. B. Davidson ; "Tone Reproduction with Electronic Stencils," R. Lant ; "Electronic Engraving," G. S Allen, 6.30 p.m.——S. WALES SECTION : University College of South Wales and Monmouthshire, Cardiff, "Magnetic Amplifiers," O. I. Butler, 6.30 p.m.

CEMENT AND CONCRETE ASSOCIATION

Tues., Jan. 31st.—Ministry of Works Building, Ashley Street, Birmingham, "Weathering and Deterioration of Concrete and Cement Rendering," C. Hobbs, 7.15 p.m.

ELECTRICAL ASSOCIATION FOR WOMEN

Tues., Jan. 31st.—25, Foubert's Place, London, W.1, Caroline Haslett Lecture, Miss M. S. Mitchell, 6 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Jan. 23rd.—LEEDS CENTRE : E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, 1, "Interior Lighting and Architect's Thoughts," F. Chippendale, 6.15 p.m.

Fri., Jan. 27th.—BATH AND BRISTOL CENTRE : S.W. Electricity Board, Old Bridge Street, Bath, "Plastics in the Lighting Industry," W. E. Harper, 7 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Jan. 20th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, Ministry of Works Films, 7.30 p.m.——BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, "Smoke Abatement," J. Lewis, 7.30 p.m.

Tues., Jan. 24th.—S. WALES BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, "Vehicle Maintenance," R. M. Pringle, 7.15 p.m.

Thurs., Jan. 26th.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, "Work Study," F. R. Curry, 7.30 p.m.

Fri., Jan. 27th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, "Industrial Hydraulics," 7.30 p.m.

Mon., Jan. 30th.—W. AND E. YORKSHIRE BRANCH : The University, Leeds, "An Introduction to Atomic Energy," J. A Dixon, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Sat., Jan. 21st.—E. MIDLANDS BRANCH : College of Art, Derby, "Gases in Cast Iron," H. Morrogh, 6 p.m.

Tues., Jan. 24th.—COVENTRY SECTION : Room A5, Technical College, Coventry, "Developments in Mould and Core-Making Processes," A. Tipper, 7.30 p.m.

Wed., Jan. 25th.—BIRMINGHAM BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Metallurgy of Cast Iron," H. Morrogh, 7.15 p.m.

Thurs., Jan. 26th.—NORTHAMPTON SECTION : Hind Hotel, Wellingborough, "Master Pattern-Making Aids Production," H. Wilson, 7.30 p.m.

Fri., Jan. 27th.—FALKIRK SECTION : Temperance Cafe, Leit Riggs, Falkirk, "Further Thoughts on Cupola Practice," W. Y. Buchanan, 7.30 p.m.

INSTITUTE OF FUEL

To-day, Jan. 20th.—SCOTTISH SECTION : Royal Technical College, Glasgow, "Modern Gas Production," J. E. Tully and D. J. A. Mansell, 7 p.m.

Thurs., Jan. 26th.—E. MIDLAND SECTION : Gas Showrooms, Lecture Theatre, Nottingham, "Recent Developments in Fuel Technology," A. L. Roberts, 6.15 p.m.——MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Occurrence, Extraction and Properties of Germanium," A. R. Powell, 6 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Jan. 23rd.—S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, 6 p.m.

Tues., Jan. 24th.—85, Minories, London, E.C.3, "Experiences in Ten Vessels—Seventy-Five Voyages with Harland and Wolff Opposed-Piston Engines Burning Boiler Oil," A. G. Arnold, 5.30 p.m.

Thurs., Jan. 26th.—N.E. COAST SECTION : Stephenson Building, Claremont Road, Newcastle upon Tyne, "Gas Turbines," J. R. Bolter, 6.15 p.m.

Mon., Jan. 30th.—MERSEYSIDE AND N.W. SECTION : Old Swan, Technical College, Liverpool, "The Construction of the Ship," G. Ridley Watson, 7 p.m.

INSTITUTE OF NAVIGATION

To-day, Jan. 20th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Some Meteorological Aspects of High-Level Navigation," "Jet Streams in Flight," B. C. Frost, "Forecasting Jet Streams," J. K. Bannon and T. H. Kirk, 5 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Jan. 26th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "The Development of a Steam-Operated Refrigerator Van," H. I. Andrews, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Jan. 23rd.—SCOTTISH CENTRE : North British Hotel, Edinburgh, "Lubricants and Greases for Road Transport Vehicles," E. M. Dodds, 7.30 p.m.

Tues., Jan. 24th.—N.E. CENTRE : Three Tuns Hotel, Durham City, "Lubricants and Greases for Road Transport Vehicles," E. M. Dodds, 7 p.m.

INSTITUTE OF WELDING

To-day, Jan. 20th.—SHEFFIELD BRANCH : College of Technology, Rotherham, "Some Fabrication Aspects in Atomic Energy," R. Glanville, 7 p.m.

Tues., Jan. 24th.—LEEDS BRANCH : Griffin Hotel, Leeds, "Metal Spraying by the Wire Process," H. J. Plaster, 7.30 p.m.

Fri., Jan. 27th.—BIRMINGHAM BRANCH : Colmore Room, Grand Hotel, Birmingham, "Unusual Welding Jobs," F. Clark, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Jan. 24th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Grain Damage During Combine Harvesting," F. S. Mitchell, 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Jan. 25th.—Large Lecture Theatre, King's College, London, W.C.2, "Control of Corrosion in the Heavy Chemical Industry," D. R. Himsworth and W. D. Clark, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 24th.—Great George Street, Westminster, London, S.W.1, "Oxton By-Pass Extension," R. A. Kidd, 5.30 p.m.

Wed., Jan. 25th.—MIDLANDS ASSOCIATION : Room 129, Civic Centre, Birmingham, "Space Flight," R. B. Beard, 6 p.m.——YORKSHIRE ASSOCIATION : Blue Bell Hotel, Scunthorpe, "Brittle Fracture Problems in Steel Construction," G. M. Boyd, 6.30 p.m.

Thurs., Jan. 26th.—Great George Street, Westminster, London, S.W.1, "Construction of a 60in Diameter Outfall Sewer for Morecambe and Heysham Corporation," J. K. Brooks and J. S. D. Brown, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 23rd.—RADIO AND MEASUREMENT SECTIONS : Savoy Place, London, W.C.2, "Particle Accelerators," E. R. Wiblin, 5.30 p.m.

Wed., Jan. 25th.—SUPPLY SECTION : Savoy Place, London, W.C.2, "Co-ordination of Overload Capacity," opened by H. G. Bell, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 24th.—39, Elmbank Crescent, Glasgow, "Recent Developments in Lubricants for Use in Marine Equipment," V. W. David and L. J. Richards, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 20th.—GENERAL MEETING : 1, Birdcage Walk, London, S.W.1, Thomas Lowe Gray Lecture, "Marine Reduction Gearing," A. W. Davis, 5.30 p.m.

Tues., Jan. 24th.—EASTERN AND SOUTHERN BRANCHES : Good Companions Hotel, Slough, "Some Engineering Aspects of a Public Water Supply," T. Irvine Hudson, 7.30 p.m.——S. WALES BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, "Fatigue of Metals and Materials," H. C. H. Gurney, 6 p.m.——N.W., A.D., CENTRE : Transport Offices, 24, Hatton Gardens, Liverpool, 3, "The Application of Plastics to the Manufacture of Automobile Bodies and Components," D. S. Mahon, 7.15 p.m.——YORKSHIRE GRADUATE SECTION : Engineering Department Lecture Theatre, The University, Sheffield, "Shock Absorption —A Problem for the Engineer," W. P. Polling, 6.30 p.m.

Wed., Jan. 25th.—STEAM GROUP : 1, Birdcage Walk, London, S.W.1, Discussion, "Problems in the Erection of Power Stations," 6.45 p.m.——E. MIDLANDS GRADUATES' SECTION: Lecture Theatre, Technical College, Loughborough, Technical Film Show, 7.15 p.m.

Thurs., Jan. 26th.—WESTERN A.D. CENTRE : Royal Hotel, Bristol, "Commercial Vehicle Structures," P. Brunton, 6.45 p.m.

Fri., Jan. 27th.—GENERAL MEETING IN CONJUNCTION WITH THE EDUCATION GROUP : Three Papers on "Sandwich Courses," D. A. Wrangham, R. McCrae and W. K. Rooney, 5.30 p.m.

INSTITUTION OF MINING ENGINEERS

Thurs., Jan. 26th.—Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1, Annual General Meeting, 11.45 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Jan. 23rd.—MANCHESTER SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, "Production of Agricultural Implements," D. I. Macdonald, 7.15 p.m.

Tues., Jan. 24th.—TEES-SIDE SECTION : Technical College, Darlington, "Mechanical Handling of Material," F. T. Dean, 7 p.m.

Wed., Jan. 25th.—SHREWSBURY SECTION : Technical College, Shrewsbury, "Synthetic Resin Adhesives," M. C. Dixon, 7.30 p.m.——WORCESTER SECTION : Cadena Cafe, Worcester, "Transfer Machines," H. W. Holbeche, 7.30 p.m.

Thurs., Jan. 26th.—LINCOLN SECTION : Ruston Club, Unity Square, Lincoln, "Rubber Reduces Maintenance and Improves Working Conditions," M. Horovitz, 7.30 p.m.

Fri., Jan. 27th.—S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, "Electro Spark Machining," A. D. P. Tallents, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Jan. 20th.—S.W. COUNTIES BRANCH : Duke of Cornwall Hotel, Plymouth, "The Development of Plastic Design," J. F. Baker, 7 p.m.

Thurs., Jan. 26th.—11, Upper Belgrave Street, London, S.W.1, "Steelwork in Transit Shed 102, Southampton Docks," F. M. Bowen and B. E. S. Ranger, 6.30 p.m.

Fri., Jan. 27th.—MIDLAND COUNTIES BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Design of Crane Gantries and the Action of Cranes on the Tracks," P. M. Worthington, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 20th.—INFORMAL MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "Some Notes on the Flow of Plastic Solids," R. F. Twist, 7 p.m.

Fri., Jan. 27th.—INFORMAL MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "Principles of Fuel Technology," S. A. Danton, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 27th.—Mining Institute, Neville Hall, Newcastle upon Tyne, "Nuclear Reactors for the Generation of Power," C. E. Iliffe, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Jan. 24th.—SCOTTISH BRANCH : North British Hotel, Princes Street, Edinburgh, "Weigh-Batching and Control of Concrete," P. Russell, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 24th.—SECTION LECTURE : 4, Hamilton Place, London, W.1, "Low Consumption Jet Engines," A. A. Lombard, 7 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Jan. 24th.—B.I.S.R.A., Hoyle Street, Sheffield, Annual General Meeting, 7 p.m.

SOCIÉTÉ DES INGENIEURS CIVILS DE FRANCE

Wed., Jan. 25th.—BRITISH SECTION : Institution of Civil Engineers, Great George Street, London, S.W.1, "Reflections on Civil Engineering Practice," Leslie Turner, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., Jan. 26th.—MANCHESTER BRANCH : Manchester Room, Central Library, Manchester, "Industrial Heating," J. Eddyshaw, 7 p.m.